

Gardenwise



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The durian-like fruits of the pandan *Benstonea affinis*, featured in this edition of 'What's Blooming'.
(Photo credit: Amanda Loh)

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Message from the Director



(Photo credit: Tan Puay Yok)

Few people will disagree that the COVID-19 pandemic is the single most disruptive event that has affected this current generation in possibly every society on Earth. Even for countries which have low community infections and have escaped relatively unscathed, the unfolding effects of COVID-19 on global supply chains, trade and the world's economy will surely mean that no country will escape the economic aftermath one way or another. Even as I write this message, the World Health Organization has assessed the current global situation to be serious and dangerous as infection rates are still climbing in many parts of the world, and a second wave of infection remains a clear and present danger even in countries that have seemingly 'flattened the curve'. COVID-19 is the greatest disruptor of national and global systems in many decades.

The Singapore Botanic Gardens, like many other gardens in the world, had to adjust its operations when COVID-19 hit Singapore with the first confirmed case in late January 2020. As the infection numbers increased, safe distancing measures were implemented, which culminated in the imposition of a semi-lockdown of non-essential services during the Circuit Breaker period from 7 April to 1 June 2020. Over this period, other than closing our carparks, the indoor air-conditioned venues and two of our gated attractions, the Gardens remained open throughout.

Perhaps not surprisingly, after accounting for the total cut in tourist visits and the impact of carpark closures, visitorship from April to June 2020 from locals had remained largely at pre-COVID levels. When the carparks, indoor venues and gated attractions reopened in mid-June 2020, the Gardens' visitorship quickly returned to pre-COVID levels. This is despite the fact that we have yet to resume our guided walks, outreach and education programmes, as well as our hugely popular concerts at

Shaw Foundation Symphony Stage and movie screenings at Eco-Lake. And the visitorship numbers are not low – we received well in excess of 200,000 visits each month from the Circuit Breaker till now.

The sustained level of visitorship is not surprising. There are numerous accounts from all over the world that there is a heightened appreciation of the value of parks, gardens and green open spaces in cities during the pandemic. In Singapore when most of our other public spaces were closed, parks, gardens and other green spaces were the only places where our residents could go outdoors safely to exercise or experience urban nature. But keeping the Gardens open during the crucial period was not without challenges – keeping up with essential horticulture operations with a severely reduced number of contract workers, ensuring that our visitors followed safe distancing rules, and ensuring that all our work could continue with the split-team system for the Gardens' staff. Overall, the Gardens overcame these challenges very well, thanks to the dedication of all staff. I also suggest that this episode has several silver linings that we can take heed of.

First, COVID-19 gave us time to pause and review what we do. Several of our branches reduced or suspended their normal operations – education and outreach, events and exhibitions, shows and festivals, and our public library – and used the time to review their core work areas. I am glad that over this period, our staff completed several reviews, such as the education and outreach framework and programme, the Gardens' interpretation guidelines, the proposal to digitise the library's collection and archives, and harmonisation of the Gardens' material transfer agreements, to name a few.

Second, COVID-19 has fostered teamwork. I am very pleased, and proud that staff from different branches have rallied behind

colleagues from the Visitor Management and Security team and contributed their time to help ensure safe distancing measures among visitors over this period. In fact, this has also given many staff a good opportunity to see the nooks and corners of the Gardens which they otherwise would not normally visit. When one of the horticulture teams was issued a two-week stay home notice as a precautionary measure, other teams covered their duties on top of their own areas and made sure that the routine works continued. It also showed the foresight in planning for a split-team arrangement to ensure that our operations can continue when one team is affected.

Third, COVID-19 has nudged us to move faster with engaging our visitors and followers in the virtual world. We have stepped up our efforts to share the Gardens' collections, heritage features and landscapes through digital media, and will launch a digital production every month. The blockbuster so far has to be our first virtual City in Nature Concert – Symphony in the Gardens – done in partnership with the Singapore Symphony Orchestra (SSO) and in celebration of the fifth anniversary of our inscription as Singapore's first UNESCO World Heritage Site. Compared to the annual SSO concert, which is the most attended single-day event in the Gardens that draws crowds of 5,000 to 6,000, around 23,000 people tuned in on 26 July 2020 to enjoy this virtual performance. Please look out for more digital content produced by the Gardens on our website.

Last, it has become clearer that the Gardens should take this chance to examine how it runs its maintenance operations, and look into areas where it can cut down and step up, and work processes that can be reorganised, including the deployment of contract workers through its contracts. Observations from the past several months suggest to me that there is still room for improvement.

While we have not escaped the repercussions of COVID-19, the most important take-away for us must be that we can innovate and adapt our approaches to continue to deliver our mission of connecting plants and people. As the Gardens progressively resumes its operations over the next few months, we look forward to having our visitors enjoy our full range of amenities and programmes again. It has been heartening that the Gardens continued to meet the needs of our visitors for outdoor spaces during the Circuit Breaker, and now, seeing children frolicking and families enjoying a quiet spot on our beautiful lawns again must count as one of the most satisfying experiences that the job offers.

Tan Puay Yok
Group Director
Singapore Botanic Gardens

The first recorded flowering of a heritage *Shorea gratissima* in the Gardens' Rain Forest

The Rain Forest is one of the last remaining patches of primary old growth forest in Singapore and has largely remained preserved throughout the history of the Gardens. At just 6.2 hectares, it is a national treasure for its rich biodiversity. The Rain Forest is home to more than 500 species of flora, including a *Shorea gratissima* Heritage Tree that caught our attention when it flowered recently.

Shorea gratissima, commonly known as the Meranti Laut, is a forest giant from the Dipterocarp family. It is found in Peninsular Malaysia, Singapore, Thailand, Myanmar, Sumatra and Borneo, and is Critically Endangered throughout this range due to threats from habitat conversion and logging, as are many other members of its family. Based on surveys in Singapore's nature reserves, there are an estimated 50 large

specimens remaining in the wild, but the Heritage Tree in the Gardens is the only publicly accessible one. With a height of 35 m and a girth of 4.5 m, it is estimated to be older than the 161-year-old Gardens and was conferred its Heritage Tree status in 2012. There are currently no records of smaller trees or seedlings in Singapore, suggesting a lack of natural succession of *Shorea gratissima* here. As the existing individuals will



(Clockwise from top left) *Shorea gratissima* flowers, fruit and leaves on a fertile branch. (Photo credits: Ng Xin Yi, Beverly Tan, Edmund Chia)

eventually decline over time, the species is at risk of local extinction.

Mature *Shorea gratissima* trees are emergent rainforest species that can reach heights of up to 60 m. In order to withstand exposure to increased temperatures and wind speeds at such heights, these trees have evolved to have relatively small, waxy leaves to minimise water loss. They have alternate, stalked leaves that are leathery in texture and oval in shape. The wings on the ovoid fruit have evolved for seed dispersal by wind, and it is from this characteristic that the family name Dipterocarpaceae is derived, meaning ‘winged-fruit’ in Greek. Like other *Shorea* species, *S. gratissima* has a five-winged fruit, with three of the wings being longer than the other two.

The tree in the Rain Forest was first observed to be flowering in February 2020 by staff from the herbarium. At that point, there were no specimens of the reproductive parts of this individual in the herbarium, and so it is possible that this was the first time it had flowered. Following the discovery, the Gardens’ Horticulture and Operations team applied a rigorous fertilizing regime to the specimen, intending not just to improve foliage growth and the tree’s general condition, but more critically to encourage flowering and fruiting.

A month later in March, fruits started developing on the tree. The Gardens’ arboriculture staff were activated to collect specimens for the herbarium, as well as vital propagation material for our Plant Resource Centre. With this material, we hope to nurture the next generation of this Critically Endangered species and improve its chances for recovery in Singapore.

Beverly Tan
Lai Simin
Horticulture and Operations



(Top) The Heritage *Shorea gratissima* flowering in the Rain Forest, and (bottom) collection of fertile branches. (Photo credits: Paru Athen, Edmund Chia)

Gongronema wallichii rediscovered after 198 years

The genus *Gongronema* includes about 15 species, all of which have flowers characterised by an urceolate corolla and staminal corona with a swollen base. They are found in Africa, South Asia, China and Southeast Asia. In Singapore there is only one known species, *Gongronema wallichii*, which is also found in Peninsular Malaysia and Borneo.

Gongronema wallichii is a twining climber with fibrous roots. It has whitish to pale grey bark with small lenticels and produces a clear exudate from its leaves and stems. Its leaves are elliptic to lanceolate in shape, with five or six secondary veins on each side of the midrib. Interestingly, the leaves of seedlings and plants growing in the shade are greyish blue-green, while those growing in brighter conditions are paler green in colour. The flowers are reminiscent of many *Dischidia* species that also have an urceolate corolla, but *Dischidia* species are generally epiphytes rather than climbers. The flowers of *G. wallichii* have the basally swollen corona lobes characteristic of the genus, which are also not observed in *Dischidia*. In *G. wallichii*, the flowers are borne on peduncles originating in between the base of the petioles, and which can repeatedly bear new flowers.

Specimens of *Gongronema wallichii* were first collected by the Danish-born botanist Nathaniel Wallich, who was the superintendent of the Calcutta Botanic Garden from 1815 to 1846. In 1822, due to ill health, Wallich decided to travel to Penang and Singapore in the hopes of recovery. He stayed for five months in Singapore, where he met Stamford Raffles and extensively botanised. In 1834, Robert Wight, a Scottish surgeon-botanist, described



Seedlings of *Gongronema wallichii* in the rainforest understorey with greyish-blue leaves.
(Photo credit: Yeoh Yi Shuen)



Plants have also been found growing beside a stream in the Central Catchment Nature Reserve.
(Photo credit: Yeoh Yi Shuen)

the new species as *Gymnema wallichii* based on one of Wallich's specimens from Singapore. However, in 1844 the species was re-classified in the genus *Gongronema* by French botanist Joseph Dacaisne. More recently, Wallich's 198-year-old specimen was studied for the revision of *Gongronema* as part of the *Flora of Singapore* project. At the time, *G. wallichii* was considered nationally extinct and this specimen was the only local material available of the species.

Rediscovery of *Gongronema wallichii* in Singapore

Recently, unusual seedlings of a climber with dark greyish blue-green leaves were spotted growing on the forest floor by one of the trails in the Central Catchment Nature Reserve. They looked similar to other climbing plants with opposite leaves, such as *Combretum sundaicum* in the Combretaceae, but were different due to the presence of colleters at the base of the leaves. Colleters are a tell-tale characteristic of species



Colleters at the base of a leaf. Colleters are glands whose general function is to produce an exudate to protect young developing leaves against water loss and pests. This function is lost in mature leaves, but their shape, size and number can be an aid to identification of species. (Photo credit: Yeoh Yi Shuen)

in the subfamily Asclepiadoideae of the Apocynaceae, and so we were able to narrow down the identity of our unknown

plant. We suspected that it could be *Gongronema wallichii* based on other vegetative characteristics, but without flowers were unable to confirm this.

A few seedlings were carefully collected in mid-2019 and taken to the Native Plant Centre at Pasir Panjang Nursery. Our attempts to cultivate the plant have been encouragingly successful thus far, with plants displaying robust growth. One of these was selected for introduction into the Gardens, and it was planted along a fence where it could freely climb. In early March 2020 it started developing flower buds, and happily, when the buds opened on the 12th of March, they revealed small urn-shaped flowers with a densely hairy corolla tube. At last we could confirm that the plants we collected were indeed *Gongronema wallichii*.

The rediscovery of *Gongronema wallichii* in Singapore after nearly 200 years is remarkable and demonstrates how careful fieldwork and propagation and horticulture skills are essential for taxonomic research. Examination of live material also revealed that the species has clear-coloured latex, a good character for the identification of sterile plants in the field that was not known before. The species is no longer Presumed Nationally Extinct; however, it is considered Critically Endangered as the known wild population is currently limited to less than 50 individuals.

With any luck, the flowers of the plant in the Gardens will be pollinated and go on to produce fruits. Seeds from these fruits would be cultivated for future reintroduction into our nature reserves and nature parks, helping in the re-establishment of healthy and self-sustaining populations of this species.

Yeoh Yi Shuen
Native Plant Centre

Michele Rodda
Herbarium



Buds and open flowers. (Photo credit: Michele Rodda)

Recognition of the Gardens' award-winning orchids

The Singapore Garden Festival (SGF) Orchid Show is an offshoot of the flagship Singapore Garden Festival, and a partnership between the National Parks Board (NParks) and the Orchid Society of South East Asia (OSSEA). Following the inaugural show in 2018, the 2nd show was planned for 1 through 8 March 2020. Unfortunately, it was cancelled due to the uncertainty about COVID-19 at the time, but the plants were still able to be submitted for judging, and we are pleased to report on some of the award-winning orchids here.

For the months leading up to the show, the orchids were vigorously growing and spiking in the National Orchid Garden's nursery and there was a wide variety of top-quality blooms. More than a hundred plants were flowering and ready for the show, but since show judging was not possible, an arrangement was worked out with the OSSEA judging committee to conduct an award judging instead. Award judging serves to set and enhance standards for cultivation and hybridization, or for the desirable forms of a particular orchid. There is a wide variety of species and hybrids that are valued for their beauty, bred for potted plants and cut flowers, and play an important role in the advancement of orchid cultivation.

A total of 16 outstanding Gardens-grown plants were selected and put up for award judging towards the end of February. These orchids were judged on five criteria

– flower colour, flower size and texture, flower shape, floral presentation, and other considerations such as the condition of the plant, rarity, difficulty of cultivation and floriferousness. Points were awarded for each of these attributes, and then the total scores were converted to a percentage to determine the orchids with the highest scores.

The following awards were given by OSSEA to the 16 plants using the following terminology:

- A First Class Certificate (FCC) was awarded to orchid species or hybrids with a score of 90% or more;
- An Award of Merit (AM) was awarded to orchid species or hybrids with a score of 80% to 89.9%;
- A High Commendation Certificate (HCC) was awarded to orchid species or hybrids with a score of 75% to 79.9%; and
- A Certificate of Cultural Commendation (CCC) was awarded to a grower in recognition of an outstanding, well grown and free flowering plant.

Several of the Gardens' award-winning orchids are showcased in this article.

Whang Lay Keng
National Orchid Garden

Grammatophyllum speciosum 'SBG Golden Tiger'

Award: FCC/OSSEA and CCC/OSSEA



Grammatophyllum speciosum is native to Southeast Asia, including Singapore. It has been recorded as the largest orchid in the world, and a large specimen can weigh up to 2 tonnes. This large and showy golden-yellow form of the species carried 10 inflorescences about 2 m long at the time of judging. The erect inflorescences bore 42 flowers and 30 buds, with each flower 11 cm across and 11 cm tall.

(Photo credit: Wong Tuan Wah)

***Mayara Mary Robinson* 'SBG'**

Award: AM/OSSEA

Mayara is a trigeneric hybrid of *Papilionanthe*, *Renanthera* and *Vanda*. At the time of judging, this entry bore one erect inflorescence with 15 flowers and four buds, with each large and showy flower 11 cm across and 11 cm tall. This hybrid was named for the former President of Ireland in 1993 during her visit to the Gardens.



(Photo credit: Emrys Chew)

***Papilionanda Xi Jinping-Peng Liyuan* 'SBG'**

Award: AM/OSSEA

A robust and free flowering cultivar, this entry had one strong upright inflorescence with around 10 large and attractive blooms at the time of judging, with each flower measuring 8 cm across. *Papilionanda Xi Jinping-Peng Liyuan* is a hybrid that was named after the president of the People's Republic of China and his wife during their visit to the Gardens in 2015.



(Photo credit: Emrys Chew)

***Vanda miniata* 'SBG Delight'**

Award: CCC/OSSEA

Vanda miniata is a miniature vanda found in Malaysia, Indonesia, Thailand, Laos and Philippines. This beautiful entry bore 14 upright inflorescences at the time of judging, with more than 450 bright orange flowers 1.5 cm across and 1.5 cm tall.



(Photo credit: Emrys Chew)

***Renantanda Anamah Tan* 'SBG'**

Award: HCC/OSSEA

This superb cultivar originated from How Wai Ron in the year 2000. At the time of judging, this entry bore 12 flowers and around 10 buds.



(Photo credit: Emrys Chew)

Singapore is famous for our cultivated antelope dendrobiums, so called because of their narrow and twisted petals which resemble pairs of horns. The Gardens has developed many outstanding hybrids using antelope Dendrobium species from Papua New Guinea.

***Dendrobium antennatum* ‘SBG Green Antelope’**

Award: CCC/OSSEA

Dendrobium antennatum is a compact species found in Papua New Guinea, Australia and the Solomon Islands. It is one of the most widely cultivated *Dendrobium* species of the section Spathulata. This vigorous and free flowering specimen carried 97 inflorescences with approximately 900 flowers at the time of judging, with each sweet-scented flower 4 cm across and 7 cm tall.



(Photo credit: Emrys Chew)

***Dendrobium* Singapore Princess ‘SBG’**

Award: HCC/OSSEA

This hybrid is a progeny of *Dendrobium discolor*. It produces two-toned flowers that are exceptional in their form and colour. At the time of judging, the long and arching inflorescences of this entry carried approximately 75 flowers.



(Photo credit: Emrys Chew)

***Dendrobium antennatum* ‘SBG D’albertisii’**

Award: AM/OSSEA and CCC/OSSEA

This majestic entry carried 108 inflorescences with over 1,000 long-lasting fragrant flowers at the time of judging, with each flower measuring 2.5 cm across and 5 cm tall. The flowers have green petals and a prominent lip that is white with purple stripes.

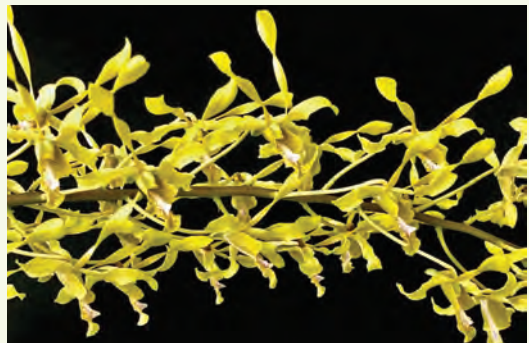


(Photo credit: Emrys Chew)

***Dendrobium gouldii* ‘SBG Golden Antelope’**

Award: HCC/OSSEA

Dendrobium gouldii has been an important parent in the breeding of potted orchids and cut flowers as it produces blooms in several colour forms, including white, yellow, purple and blue. This rare and majestic dendrobium entry bore seven inflorescences at the time of judging, with about 300 showy chartreuse yellow flowers, each measuring 5.5 cm across and 4.5 cm tall.



(Photo credit: Lim Chiauww)

***Dendrobium discolor* ‘SBG Golden Antler’**

Award: AM/OSSEA

Dendrobium discolor is frequently used for breeding to produce magnificent hybrids. Commonly called antler orchids, they produce long-stemmed inflorescences with numerous flowers. This majestic antelope dendrobium grows up to 3.5 m and at the time of judging this entry bore many beautiful golden-yellow flowers. The sepals and petals are twisted, which is a good characteristic of an antelope dendrobium.



(Photo credit: Emrys Chew)

***Dendrobium* Singapore Belle ‘SBG’**

Award: HCC/OSSEA

A progeny of *Dendrobium discolor*, *Dendrobium* Singapore Belle is a compact, free-flowering hybrid. At the time of judging, this entry bore two upright and sprightly inflorescences with 15 well-arranged flowers.



(Photo credit: Emrys Chew)

***Dendrobium gouldii* ‘Nong’**

Award: FCC/OSSEA

This form of *Dendrobium gouldii* is large and robust with rare violet flowers. At the time of judging, this entry bore 17 inflorescences with approximately 500 flowers in total, each measuring 5 cm across and 4 cm tall. The flowers are attractive, with white sepals overlaid with purple, and indigo-violet petals that are erect and twisted, resembling antelope horns.



(Photo credit: Emrys Chew)

Field work in the Bidoup-Nui Ba National Park of Vietnam

Our first impression of Da Lat was the cool night temperature of 14 degrees Celsius. We arrived at night on the 9th of February 2020, with our destination being the Bidoup-Nui Ba National Park (BNBNP) 40 km away in the Central Highlands. The park was established in 2004 and was named after the two highest peaks on the Langbiang Plateau, Bidoup and Nui Ba. With a size of 66,047 hectares, it is one of the five largest national parks in Vietnam (in comparison, the Singapore Botanic Gardens is 82 hectares). We were there to botanise the forests within BNBNP, and to make collections of fertile (flowering or fruiting) material as part of a Memorandum of Understanding (MoU) between BNBNP and the National Parks Board (NParks).

This was our fourth collaboration with BNBNP and for this trip, we planned a five-day botanical survey along various trails in subtropical montane forest habitats between 1395 and 1524 m in altitude. The areas we botanised can be characterised as evergreen coniferous broad-leaved mixed forests with pines, oaks and laurels as the dominant species. The forest canopy is about 25 to 35 m high, and one of the oldest trees in the park is a 1,300-year-old *Fokienia hodginsii* belonging to the Cypress family (Cupressaceae). Another large tree relative found in the forest, *Dacrycarpus imbricatus* (Podocarpaceae) produces yellowish wood that is used in construction and furniture. The most common species of pine that we encountered is *Pinus kesiya*, the Khasi Pine. Also known as the Three-needled Pine, this species typically occurs between 900 and 1400 m in altitude, can form stands along ridges and reaches up to 30 m in height. The species is known for regenerating in slash and burn areas, and as a result it is used for forest regeneration within the park. BNBNP practices the use of controlled burns to clear undergrowth that may otherwise spark wildfires in the dry season and



Fokienia hodginsii, a taxon represented by some of the oldest trees in the area.
(Photo credit: Serena Lee)

wipe out swathes of forest, and *Pinus kesiya* is the main species used for reforestation in these burned areas.

We encountered several oaks during our survey, although the dropped

acorns strewn on the forest floor told us that we had missed their fruiting season. However, we did find an out-of-season *Quercus* species in full bloom. We also found a specimen of *Quercus braianensis* which had grown to an

impressive height of 30 m with a trunk diameter of over a metre. Other large trees that we encountered were several Lauraceae species, a flowering *Garcinia* (relative of mangosteen) with orange-yellow sap, and several *Ficus* including one that produced figs on stolons running along the ground. Smaller trees included several *Saurauia* species, one of which, *S. napaulensis*, has edible miniature green fruits that are eaten by locals and taste like kiwi fruits (of the same family, Actinidiaceae), a small *Rhododendron* tree with attractive white flowers, and *Betula alnoides* of the Birch family (Betulaceae) with pendulous male catkin inflorescences.

Typical of the forests of this region, many of the understorey treelets or shrubs that we encountered belong to the genera *Ardisia* and *Lasianthus*, with the former producing pinkish star-shaped flowers and red to purplish black fruits and the latter red to bluish fruits when ripe. At the forest margin, we collected a beautiful *Melastoma* species with lipstick-red flower buds opening to expose large petals that are pinkish on top and white with reddish purple streaks on the underside.



Mixed Fagaceae fruits. (Photo credit: Paul Leong)

Of the herbaceous plants that we found, a pink-flowered *Impatiens* and an *Anemone* with white large flowers, *A. sumatrana*, would not be out of place in a garden and certainly have horticultural potential. The colour blue is rare in plants, especially in the tropics, but we chanced upon several herbs with flowers or fruit in shades of blue – namely a *Lobelia* with lilac-blue petals shaped like a small moth with patterns and appendages to complete the mimicry, a *Gentiana* with beautiful purple-blue star-shaped tubular flowers complemented by dark glossy green leaves, a *Torenia* with arching purple-blue flowers, and a species of *Ophiopogon* with glossy blue fruits. There are purportedly more than 250 species of orchids in BNNBP, and we did encounter quite a few of them. Unfortunately, most were not blooming at the time, but we did manage to find three species in flower, including *Holcoglossum auriculatum* with rather large white attractive wavy flowers. Of special mention is a large almost prehistoric looking climbing fern, *Diplopterygium longissimum*, encountered at a forest clearing scrambling over trees and shrubs. In habit, it resembles our Resam, except with larger fronds and much larger stature, it is akin to *Dicranopteris linearis* on steroids!

Perhaps the most delightful finds on our trip were two root parasites. We found a dioecious species of *Balanophora* (Balanophoraceae) growing next to a tree in the Laurel family. Its male and female flower parts are produced on separate subterranean tuber-like growths, with the inflorescences emerging from the ground. We sometimes saw these growing side by side but not always. We observed that some of the female 'tubers' produced single inflorescences, while others had up to five or more inflorescences each. Above ground, the female inflorescences are globe-like in shape, with a pinkish-red stigmatic surface and several reddish bract-like structures below. The male 'tubers' appeared to have only one inflorescence, with many staminate flowers arising from it. The perianth is reddish with prominent white anthers.



Garcinia sp., a wild mangosteen.
(Photo credits: Serena Lee)



Our guide and tree climber Ko Sa En Luy, the amazing Spiderman!
(Photo credit: Paul Leong)



A lovely *Impatiens* species of horticultural potential.
(Photo credits: Paul Leong)



Another plant of horticultural potential, *Anemone sumatrana*. (Photo credits: Paul Leong, inset Serena Lee)



Blue flowers and fruits found on our collecting trip: (top left and centre) *Lobelia* sp., (top right) *Torenia* sp., (bottom left) *Gentiana* sp., and (bottom centre and right) *Ophiopogon* sp. (Photo credits: Paul Leong, except *Gentiana* sp., Serena Lee)

The other notable root parasite that we found, *Mitrastemon yamamotoi* of the family Mitrastemonaceae, is parasitic on oaks and its flowers are singular and seen emerging directly from the roots. Its flowers are protandrous, going through a male phase before transforming into their final female form. The pistillate flower structure is pinkish cream with a couple of creamy bract-like structures below. In total, we collected 116 herbarium specimens, most with another three sets of duplicates. One set will be deposited in the Southern Institute of Ecology Herbarium (SGN) in Vietnam and another lodged in the Singapore Herbarium (SING). The other duplicates will be sent to the herbarium of the Royal Botanic Gardens, Kew (K) and other herbaria where there are experts studying the plant taxa collected. The families that are most represented in our botanical collection from BNNP are the Rubiaceae, Primulaceae, Lauraceae, Acanthaceae and Melastomataceae in descending order. In terms of genera, most of the species that we collected belong to *Ardisia*, *Smilax* and *Ficus*.



The juiciest *Smilax* fruits that we have ever seen!
(Photo credit: Paul Leong)



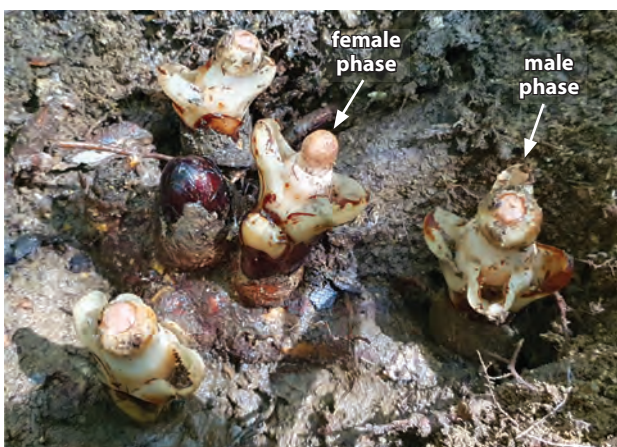
Balanophora sp.
(Photo credit: Paul Leong)



During our time in Da Lat, we saw *Balanophora* species for sale in the night market. Locally, they are soaked in alcohol and used as a treatment for male impotency. (Photo credit: Serena Lee)



The collection team, from left to right: Paul (Gardens' staff), Huynh (driver), Courtney (intern), Serena (Gardens' staff) and En Luy (guide).
(Photo credit: Serena Lee)



Mitrastemon yamamotoi. (Photo credit: Serena Lee)

As an intern completing a two-month attachment with the Singapore Botanic Gardens' herbarium, I was very fortunate to be able to join the collecting trip in Vietnam. Having briefly learnt about collecting and pressing herbarium specimens during my degree studies in Australia, it was great to put these skills into practice. Compared with the mostly sclerophyllous shrubs and annual herbs that I have collected in Victoria, the large leaves and fleshy fruits of tropical plants present a different set of challenges when it comes to creating dried specimens for identification. I was very impressed with the make-shift drying oven that Serena rigged up in our accommodation using a portable heater and a large plastic sheet. Coming from the temperate climate of Melbourne, the flora of Vietnam was very foreign to me. On the trip I encountered many new families, most interesting of which were the Balanophoraceae and Smilacaceae. One beautiful *Smilax* that we collected late one afternoon had bunches of large, juicy grape-like fruits hanging over the path and I was surprised to discover it was not a Vitaceae. The skills and field experience gained on this trip will certainly be useful going forward in my botanical career.

Courtney Taylor

Paul Leong
Serena Lee
Herbarium

Courtney Taylor
La Trobe University, Australia

Native *Dracaena* in Singapore – part 3, the Short-flowered *Dracaena*

There have been many interesting plant discoveries made in Singapore in recent years. Some of these are new species to science, while others are new records for Singapore. These new records involve plants that are already known from other countries but that have never been collected and documented in Singapore, although a lot of them are native and have grown here all these years. In our previous *Gardenwise* articles (see volumes, 51, 52 and 53) we have shared that *Dracaenas*, often known as dragon trees, are charismatic and popular plants. As we work on more of these species, it becomes clear that not much is known about the genus in Southeast Asia, and there are new discoveries to be made even in Singapore. Here we introduce you to a strange species that was only known from Malaysia until we spotted it recently in Singapore's forests!

As we were surveying populations of *Hanguana* in the Central Catchment Nature Reserve, we encountered individuals of an interesting plant with arching leaves and a long and narrow petiole-like leaf base. They looked just like some of the stout species of *Hanguana*, such as the Singapore endemics *H. rubinea* and *H. triangulata*, except that they were much smaller. We continued to monitor them regularly, hoping to see their flowers. Luckily, we didn't have to wait too long and within a year we could see horizontal inflorescences emerging close to the ground. Once we had seen their white tubular flowers with six identical small tepals, there was no doubt that the plants belong to the family Asparagaceae and to the genus *Dracaena*!

The flowers, which were much shorter than in all of the other



The Short-flowered *Dracaena*, in habitat in the Central Catchment Nature Reserve. (Photo credit: Jana Leong-Škorníčková)



The habit of the Short-flowered *Dracaena*. (Photo credit: Jana Leong-Škorníčková)

Southeast Asian species we had seen before, allowed us to also firmly identify it as *Dracaena breviflora*. Commonly known as the Short-flowered *Dracaena*, it is an unusual member of the genus. It was described by Henry Ridley,

the first director of the Gardens, in 1896. He named it '*breviflora*' for its short flowers, which are only about 12 mm long from the base of the flower to the tip of the petals. The plant has other unusual characters as well – for instance, unlike many



A plant in flower.
(Photo credit: Matti Niissalo)



A close-up showing a prophyll.
(Photo credit: Jana Leong-Škorníčková)



An inflorescence. (Photo credits: Matti Niissalo)

other *Dracaena*, it lacks a distinctive trunk. Instead, it produces a thin stem that doesn't seem to thicken much with age – it would definitely be better called a dragon herb instead of a dragon tree! The revelation of its identity was exciting as this was the first record of the

species in Singapore, and indeed, the first outside of Peninsular Malaysia! Even in Malaysia, the species seems to be rare, as only a few collections of it exist in the world's herbaria, and most of these are very old. Luckily, some of the areas from where the species was

previously recorded are within protected forests.

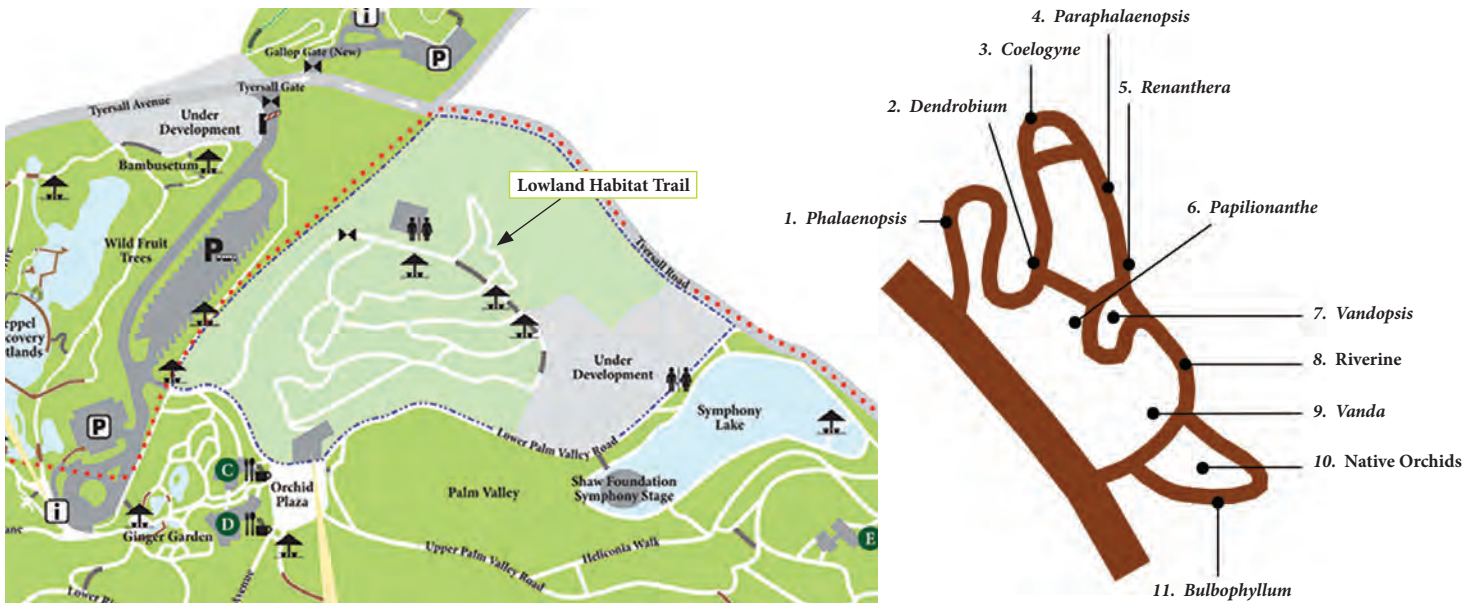
Dracaena breviflora is well protected in Singapore, as all plants are within a nature reserve. However, the known population is very small, and only a handful of plants have been recorded. We will continue monitoring these plants in the hopes of collecting ripe seeds for propagation, both in the nursery as well as in tissue culture, to help increase the number of individuals in Singapore.

While *Hanguana* species and our newly discovered *Dracaena* share superficial similarities, they are not closely related. It is possible to tell them apart even when not in flower, but one has to look closely. While *Hanguana* species grow continuously, *Dracaena* species often take breaks between flushes of leaves. During these breaks, they produce small scale-like triangular leaves called prophylls, which are absent in *Hanguana*. These scales were the first indication that our mystery plant was not a *Hanguana*, but we had to wait for it to flower before we could confirm its identity. With its unusual growth form and flowers, our discovery considerably increases the morphological diversity of *Dracaena* in Singapore. We suspect that it will not be the last discovery to be made among Singapore's *Dracaenas*, but there is little doubt that it is the most distinctive looking!

Matti Niissalo
Molecular Biology Laboratory

Jana Leong-Škorníčková
Herbarium

Orchid collections along the Lowland Habitat Trail of the National Orchid Garden



Maps showing (left) the location of the Lowland Habitat Trail within the National Orchid Garden, and (right) the collections of orchids that can be found along the trail.

In March 2020, a refreshed trail was opened to visitors of the National Orchid Garden. Called the Lowland Habitat Trail, it begins near the Vanda Miss Joaquim display in the garden. The trail exhibits more than 120 different orchids that are associated with lowland habitat types in the region, such as Neram forests and lowland streams. Showcased here are some of the orchid collections that can be found along the Lowland Habitat Trail.

1. *Phalaenopsis*

More commonly known as moth orchids, both standard types and novelty types can be found in this collection. Standard types have larger flowers with pronounced lateral petals, while novelty types are more compact in size, free-flowering and produce flowers in many colours. Some of the novelty-type *Phalaenopsis* are prized for their strong scents and rare colours, such as the albino (alba) variants.



Phalaenopsis flowers are fragrant to attract pollinators. The emission of scents in (left) *P. bellina* and (bottom left) *P. violacea* is triggered by light during the day time.



2. *Dendrobium*

Several sections of the genus *Dendrobium* can be found in this collection, including Crumenata, *Dendrobium* and Spatulata. Representatives of the Crumenata section are notable in this collection. These plants have stems that are swollen at the base and bear flattened leathery leaves. Their flowers are typically short-lived and bloom after a sudden drop in temperature, such as after heavy rains.

Species belonging to the section *Dendrobium* are usually deciduous. These plants will shed their leaves, leaving behind bare canes that will produce flowers at nodes along the canes. Species which are commonly known as the 'antelope orchids' belong to the section Spatulata. The flowers of these species have characteristic twisted petals that resemble the horns of an antelope.



(Top) *Dendrobium crumenatum* in the section Crumenata, and (bottom) *Dendrobium lineale* 'Blue' in the section Spatulata.

3. *Coelogyne*

There are about 190 to 200 species in the genus *Coelogyne*. Species in this genus are characterised by having one or two pleated leaves that grow from a pseudobulb and are often difficult to differentiate in their vegetative state. Nevertheless, *Coelogyne* are valued for their fragrant and showy inflorescences.



The Black Orchid, *Coelogyne pandurata*, grows epiphytically and terrestrially near rivers. Its flowers are fragrant and easily identified by the ornate black markings on the lip.

4. *Paraphalaenopsis*

Paraphalaenopsis is a small genus with four species. They are commonly known as 'rat-tailed' orchids because of their terete, cylindrical leaves that resemble the tails of rats. The flowers of this genus are showy and usually emerge as a cluster at the base of the plant.



Paraphalaenopsis laycockii produces densely flowered inflorescences with up to 15 fragrant flowers.

5. *Renanthera*

There are 20 species in this genus. The name *Renanthera* refers to the kidney shape of the pollinia and is derived from the latin word *renis* meaning 'kidney' and the Greek word *anthera* meaning 'anther'.



Renanthera histrionica grows naturally in lowland forests and mangroves. It has petals and sepals that arch backwards, exposing an erect column and lip.

6. *Papilionanthe*

Orchids in the genus *Papilionanthe* are characterised by their thin stems with alternate terete leaves and flowers that look like butterflies. There are 11 species in this genus, and all species require full sun for optimal growth and flowering.



Papilionanthe hookeriana is also known as the Kinta Weed in Malaysia because of its vigorous growth in the swampy conditions of Kinta Valley (Perak). In nature, this species can be found growing in the midst of dense growths of *Hanguana malayana*.

7. *Vandopsis*

There are four accepted species in the genus *Vandopsis*. These Vanda-like species are monopodial and produce fleshy strap-shaped leaves. Plants of this genus produce attractive flowers that are long-lasting.



Vandopsis lissochiloides is a robust and large orchid that is native to Thailand, Laos, Philippines and Papua New Guinea.

8. Riverine collection

Riverine or riparian areas are important habitat types for orchids in the region. They have high humidity and low temperatures which are suitable conditions for orchids to grow. In the lowland streams of Malaysia, it has been recorded that a single tree could host about 20 species of orchids, and possibly even more.



Coelogyne rochussenii is often found on trees overhanging rivers. The flowers close partially at night and reopen in the morning.

9. Native Orchids

There are an estimated 228 species of orchids that are native to Singapore and about 60 of these still exist in the wild. Most of them can be found growing naturally in the Central Catchment Nature Reserve. The native orchid collection exhibits more than 15 species that are native to Singapore.



Cymbidium finlaysonianum is a robust epiphytic orchid that flowers seasonally and can be grown on street trees in urban areas.

10. *Bulbophyllum*

With just over 1,800 species, the genus *Bulbophyllum* is the largest in the family Orchidaceae. Its name is derived from the Greek word *bulbos* meaning 'bulb', and *phyllon* meaning 'leaf'. This refers to the morphology of plants in the genus, which usually have a single leaf emerging from a pseudobulb.



Bulbophyllum graveolens produces umbelliform inflorescences that are long-lasting. The scent produced by the flowers is often likened to the smell of urine. (Photo credit: Dina Mardiahna)

11. *Vanda*

The genus *Vanda* has about 60 species and is one of the most commercially important genera because of their outstanding flowers. Beautiful species such as *Vanda sanderiana* and *Vanda coerulea* have been used for breeding to produce many cut-flower and potted plant varieties.



(Top) *Vanda insignis* produces flowers that are fragrant and have a white column. (Bottom) *Papilionanda* Tan Chay Yan, which put Singapore on the orchid world map, is the progeny of *Vanda insignis*.

Lim Siu Ann
Whang Lay Keng
National Orchid Garden

All images by David Lim, unless otherwise indicated

Reintroduction of native orchids at the Alexandra Canal Linear Park

The Alexandra Canal Linear Park is a unique 1.4-km-long green space that is part of NParks' Park Connector Network. Decked over Alexandra Canal, it starts from the Queenstown MRT Station and runs along Strathmore Estate before ending at Tanglin Road, where it leads to the Alexandra Park Connector. Nearby residents and visitors enjoy a range of facilities within the park, including fitness and play equipment, and it even has a challenging skate corner for avid skaters. There is a big supermarket and coffee shop along the park connector too, making it convenient for park users to pick up a drink and enjoy some nice local food. The park was opened on 11 November 2007 by the late Minister Mentor Lee Kuan Yew, who planted a Rukam (*Flacourtia inermis*) to mark the occasion. Many of the other trees found within the park are also quite young, but there are several large Rain Trees (*Samanea saman*) and Angsanas (*Pterocarpus indicus*) in the area that date to the 1960s.



Bulbophyllum blumei (indicated with the white arrow) is Presumed Nationally Extinct in the wild locally but a very adaptable species for reintroduction. Individual plants bear a single leaf, and the inflorescence produces one or two flowers around 6 cm across each. Our reintroduced plants flower and fruit regularly at the park, indicating the presence of a pollinator.



Bulbophyllum membranaceum is a Critically Endangered species that is among our smallest native orchids. Its flowers measure only about 6 mm in length and have dark red lateral sepals and petals that appear translucent. Here, the species is growing well beneath a Bird's Nest Fern (*Asplenium nidus*).



Bulbophyllum purpurascens is a lovely species that is Presumed Nationally Extinct in Singapore. It has ovoid pseudobulbs that each bear a single leathery leaf. The inflorescences are short and produce 10 to 12 pale yellow flowers. Our reintroduced plants flower several times a year, as indicated here by the presence of old flower spikes.



Coelogyne rochussenii (indicated with the white arrow) has many narrowly conical pseudobulbs which bear two leaves. The pendulous inflorescences can be as long as 70 cm and produce around 30 flowers that are pale yellow-green in colour. This species was Presumed Nationally Extinct in the wild until it was rediscovered in Singapore recently. Here, it grows next to two other species reintroduced into the park, *Bulbophyllum blumei* and *Phalaenopsis cornu-cervi*.



Phalaenopsis cornu-cervi is another Presumed Nationally Extinct species in Singapore. It is an attractive orchid that produces many sprays with numerous star-shaped, long-lasting flowers that measure 3 cm in diameter. It is a drought resistant species, with fleshy leaves and an extensive thick root system. As a result, our reintroduced plants have grown extremely well, even during times of drought.



Grammatophyllum speciosum is commonly known as the Tiger Orchid. Presumed Nationally Extinct in the wild in Singapore, its two-metre-long inflorescences bear flowers that resemble the skin of a tiger. Shown here are three Tiger Orchids planted in the middle of the park connector. The plant in the foreground flowered profusely last year, and many old flower spikes are still around.



Reanathera elongata is a Critically Endangered climbing epiphyte with thick leathery leaves. The branching inflorescences can bear many small red flowers, each about 1.5 cm long. Our reintroductions flower regularly within the park, including the one shown here in March 2020.

As a result of our native orchid reintroduction programme, visitors can also see many orchids in the park. Our work at the Alexandra Canal Linear Park started in September 2013, when we met with the park manager and surveyed the site for suitable planting locations. Due to their young age, many of the trees were not suitable hosts for our epiphytes, which prefer textured bark that helps to catch organic matter and retain water. But in the end, we found a suitable location adjacent to Queenstown Secondary School, where mature trees grew with large crowns to provide plenty of shade for the young plants. We also found a suitable terrestrial location for planting Tiger Orchids (*Grammatophyllum speciosum*) in the middle of the park connector between two HDB estates.

The planting was carried out in early October 2013, before the arrival of the rainy season which usually lasts from October to early January. The slightly cooler

temperatures and heavy rain expected during this period would provide ideal conditions for the reintroduced plants to settle into their new home. In our experience, seedlings planted during this period establish themselves quickly by producing new shoots and roots. By the end of the rainy season, the roots of epiphytic orchids should have attached themselves to the bark of their host tree so that they can absorb water and nutrients even during the dry season.

We are very happy to report that after seven years, the native orchids



Reintroduction of the native orchids at the Alexandra Canal Linear Park in October 2013. The park connector was new at the time, with many young plants.



Visitors can enjoy native orchids while walking or cycling around the park.

that we planted at the Alexandra Canal Linear Park are thriving and flowering regularly. In all, we were able to find homes for seven different species, which visitors can look out for on their next visit to this unique park.

Yam Tim Wing
Peter Ang
Felicia Tay
Research and Conservation

All photos by Dr Yam Tim Wing



The Southeast Asian Floras

In *Gardenwise* 54: 6–8 (2020) we celebrated the publication of the first three volumes of the *Flora of Singapore* and noted that we planned to publish 11 more volumes to complete the entire series. The *Flora of Singapore* is just one of a number of Flora projects in Southeast Asia and in this ‘Taxonomy Corner’ I would like to discuss our sister projects in the region.

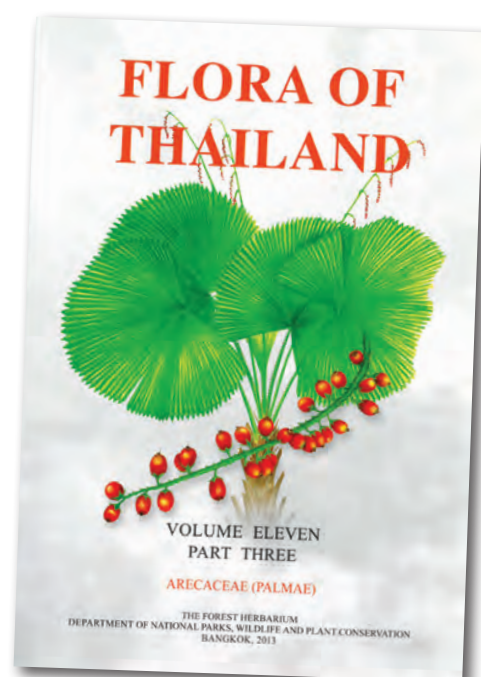
Floras are works that catalogue, describe and aid in the identification of the plant diversity of a particular region. They have historically been published as books, and continue to be so, but they can also additionally or alternatively be presented online. Amongst many reasons why putting names to the plants we see around us is important, the ability to identify plants is crucial to assess the conservation needs of native species and to monitor the naturalised and potentially invasive ones. This is as true in all of Southeast Asia as it is in Singapore. The challenge for us is that there are more than 50,000 plant species across Southeast Asia to be included in the Floras that cover the region and, as we shall see, we have a long way to go before we come close to completing the task.

The focus of each of the principal Flora projects in the region is clear from its name: *Flora of Peninsular Malaysia*, *Tree Flora of Sabah and Sarawak*, *Flora of Thailand*, *Flora of Cambodia*, *Laos and Vietnam* and *Flora Malesiana*, the last of which covers the countries of Malaysia, Singapore, Indonesia, Brunei, Philippines, Timor Leste and Papua New Guinea. In addition, a new *Flora of Myanmar* is being planned, there is a Vietnamese language *Flora of Vietnam*, and also a number of local Flora projects around the region (e.g., *Flora of Bali*). There is some or considerable overlap between several of these Flora projects.

The sister projects *Flora of Peninsular Malaysia*, launched in 2005, and the *Tree Flora of Sabah and Sarawak*,

launched in 1991, are coordinated and published by the Forest Research Institute Malaysia in Kepong. It is estimated there are around 8,300 species to be included in the *Flora of Peninsular Malaysia* and 3,500 tree species, out of around 12,000 plant species in all, in the narrower focus of the *Tree Flora of Sabah and Sarawak*. Along with Singapore, these two Flora projects are completely included within the area covered by *Flora Malesiana* (see following page). The Floras, however, complement each other rather than compete, with the narrower geographical focus of the Singaporean and Malaysian projects meaning that they will be completed sooner and be of more direct relevance to local users and planners. Transnational projects, such as *Flora Malesiana*, however, provide both a wider perspective and a template for the national Floras. By working alongside each other, especially with crossover research between the projects, they can achieve their separate but related goals.

After Singapore, Peninsular Malaysia is likely to be the best collected region within Malesia, which means that there is a greater chance of the *Flora of Peninsular Malaysia* being a true reflection of the actual plant diversity of the region (see *Gardenwise* 54: 21–23). Nevertheless, new exploration continues to lead to the discovery of new species, with around 100 having been described in recent years. So far in the *Flora of Peninsular Malaysia* it is estimated that about a third of the lycophytes and ferns have been published in three volumes and about 10% of the seed plants in seven volumes. For the first time in any of the Southeast Asian Flora projects, the *Flora of Peninsular Malaysia* routinely includes national conservation assessments for all species, a good practice also taken up by the *Flora of Singapore*. Eight volumes of the *Tree Flora of Sabah and Sarawak* have been published so far, encompassing about 64% of the estimated total number of tree species. The editorial team estimates that the remaining 36% of



the species will take another ten years to complete.

The *Flora of Thailand*, covering about 11,000 species, is arguably the most successful of the active Flora projects in Southeast Asia (not including the *Flora of Singapore* of course!). The first volume was published in 1970 and thereafter regularly, but not frequently, until around 15 years ago when the number of volumes being published increased in response to the larger number of manuscripts being submitted and an enlarged editorial board. The *Flora of Thailand* is led by Thai botanists who have enthusiastically collaborated with overseas botanists to train new generations of Thai students, to collect the specimens necessary for the taxonomic research, and in the writing of the Flora accounts. All along there has been strong Danish collaboration in the project, which has also expanded into collaboration with many other botanical institutions in Europe, mainly in the UK and the Netherlands, and Asia, particularly in Japan and Singapore. All plant families have now already been completed or have been assigned to researchers and are under active revision, primarily by



Thai botanists. The editorial board of the *Flora of Thailand* plans to publish the last volume and complete the entire Flora in 2024.

The *Flora of Cambodia, Laos and Vietnam* (known as *Flore du Cambodge, du Laos et du Viêt Nam* in French), with an estimated 10,200 species, began in 1960, initially as a supplement to the completed *Flore générale de l'Indochine*, which was published between 1907 and 1951. The *Flore générale de l'Indochine* was a huge and admirable work but suffered from becoming out-of-date rather quickly due to rapid changes in family, genus and species concepts over the course of its publication, coupled with large numbers of new species and new records being discovered in the three countries as new specimens were collected. The *Flora of Cambodia, Laos and Vietnam* was conceived as an update to *Flore générale*, both of which were coordinated and published by the Muséum National d'Histoire Naturelle in Paris, but the former evolved into a brand new Flora project which was then beset by its own problems, not least the various periods of war and instability in the region. Active participation by botanists in the three countries concerned is rather low and completion of the Flora is currently a rather distant dream.

The most ambitious of the Floras in the region is *Flora Malesiana*. The latest published estimate of the plant diversity in Malesia is 45,000 species, a truly staggering number to research and describe and yet still likely to be an underestimate. When it was first launched by the Dutch botanist C.G.G.J. van Steenis in 1948, the estimate of the number of species was 25,000–30,000 species. Van Steenis's vision was that the area demarcated for the Flora, despite being so enormous, made biogeographic sense and therefore its plant diversity should be described together in a single Flora. It was already an extremely ambitious project in 1948 and, 72 years later, only around 29% of the species have been revised and included in the published Flora. Many more species have been included in botanical publications but as they are dispersed over many different books and journals it is much

more difficult to synthesise the data. The pace of publication is clearly much too slow and there have been many and varied discussions about speeding up the research necessary to write the accounts. Despite its focus on the plant diversity of the Malesian region, the large majority of the Flora accounts that have already been published have been written by Europeans, particularly by Dutch and British botanists. This is largely due to the colonial history of the region and the concentration of both expertise and the specimens needed to do the work in European institutions. However, the accounts of several families are being coordinated by botanists in the Malesian region, particularly from Singapore, Malaysia and Brunei. In addition, the recruitment of researchers and authors to actively work on *Flora Malesiana*, along with the printing of the volumes, is now being undertaken by the Singapore Botanic Gardens. As a commitment to the completion of tropical Floras wanes in Europe, botanical institutions in the Malesian region, who rely heavily on these publications for their own work and for an understanding of the plant diversity of their own countries and regions, will need to take greater responsibility.

As noted above, there is likely to be well over 50,000 species of plants in Southeast Asia. Making sense of such a bewildering number of species and providing the tools for a variety of end-users to be able to identify them and learn more about them is the main task of the taxonomist when writing a Flora account. The taxonomist must have both a good knowledge of the plants under study and a good knowledge of the previous taxonomic literature on this group, which can stretch back over 200 years and be written in a variety of languages. Given the overlap and the scale of the task, it makes sense for the same botanist to work on multiple Floras at the same time. This ensures taxonomic rigour through observation of the plants over their range of variation, standardisation of species concepts between the different Flora projects, and is simply more efficient than having multiple botanists having to learn new plant families from scratch.

Single authors or teams of authors have contributed many accounts of families to multiple Flora projects in the region and this is much to be welcomed. Examples include several Flora accounts of Apocynaceae, Convolvulaceae, Cucurbitaceae, Cyperaceae, Lamiaceae, Myristicaceae, Polygalaceae, Polypodiaceae, Sapindaceae and many more.

There are other challenges to overcome. The editorial teams of the *Flora of Peninsular Malaysia* and the *Tree Flora of Sabah and Sarawak* have also revealed another bottleneck in the goal of making information on the plant diversity of Southeast Asia available to a wider readership: the lack of suitably qualified editors. They have warned that as they age, there is a distinct lack of people skilled enough to take up the work in the future. Also, the writing of taxonomic treatises, including Floras, does not register on the short-term radar of academic evaluation systems, such as the JCR Impact Factor, that are widely used to assess researchers in universities (but very rarely in botanic gardens). This creates a major disincentive to botanists working in universities to work on Flora projects as to do so could damage their tenure and promotion prospects.

Botanic gardens, such as the Singapore Botanic Gardens, remain the bastions of the taxonomic research necessary to write Floras. With so much plant diversity in Southeast Asia waiting to be discovered and described, the botanic gardens of the world will continue to work on Flora projects and are ideally positioned to do so with their combinations of living, herbarium and library collections, taxonomic researchers and support staff, editorial staff, and usually exhibition and educational teams to bring what is being discovered about plant diversity to a wider public. To conserve the plant diversity of Asia, first we must know what there is, but we must also create an awareness of and appreciation for plants in the wider public. Floras are but one link in the chain, but an indispensable one.

David Middleton
Herbarium



International researchers working on the *Flora of Singapore* and Southeast Asian plant diversity



(Photo courtesy of David Simpson, shown on left)

David Simpson is an Honorary Research Associate with the Royal Botanic Gardens, Kew, and also a Visiting Research Fellow in Botany with the University of Dublin, Trinity College. He serves on the editorial

board of the *Flora of Thailand*. For the *Flora of Singapore* project, Dave researched and wrote the Cyperaceae account in volume 7 (Poales) which was published in October 2019. In his treatment, he recorded 18 genera and 102 species for Singapore with *Cyperus* and *Fimbristylis* being the largest genera. Besides the Cyperaceae, Dave also works on the Poaceae and related families worldwide.



(Photo credit: Serena Lee)

Sahut Chantanaorrapint is also collaborating with the Gardens on the *Flora of Singapore* project. He will be contributing the liverwort families Frullaniaceae, Lophocoleaceae and Pallaviciniaceae, the

hornwort families Anthocerotaceae and Notothyladaceae, and leucobryoid Calymperaceae moss family. Sahut is an Associate Professor in the Department of Biology at the Prince of Songkla University, Hat Yai, Thailand. Besides the study of bryophytes, Sahut also has an interest in the taxonomy and ecology of pteridophytes, orchids and myco-heterotrophic plants.



(Photo courtesy of Ivan Savinov)

Ivan Savinov, from the Russian Federation, is a lecturer in the Department of Biology at the Moscow State University of Food Production. He visited the SING Herbarium from 19 to 31 January 2020 to study the families

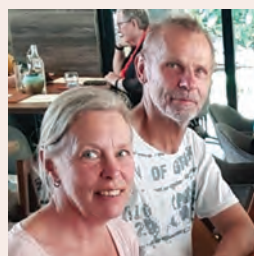
Celastraceae and Centropiaceae for the *Flora of Singapore*. Ivan is also working on the Celastraceae for the *Flora of Cambodia, Laos and Vietnam* and *Flora of Myanmar*.



(Photo credit: Koh Sin Lan)

Caroline Pannell is a familiar face at SING, having visited the Gardens a couple of times before. Caroline currently resides in Northern Ireland, where she serves as a Visiting Researcher at the Queen's University Belfast. She is also a Research Associate with the University of Oxford and the Royal Botanic Gardens, Kew.

She visited the Gardens from 19 September to 15 November 2019 to study our collections of *Aglaia* (Meliaceae), *Achariaceae* and *Salicaceae* for the *Flora of Singapore*. While here, Caroline also presented a talk entitled 'Wallace's Line and the Biogeographical Contrast between Southeast Asian and Australasian Forests' at the October session of the Gardens' Speaker Series.



(Photo credit: Serena Lee)

Helena Duistermaat is no stranger to the SING Herbarium. Born in The Netherlands, Leni was based in Singapore in the early 2000s where she was a volunteer and later staff at the Herbarium. During her time here, she published the 'Field Guide to the Grasses of Singapore (excluding the Bamboos)' in a supplement to the *Gardens' Bulletin Singapore*. Currently Leni is a Researcher

with the Naturalis Biodiversity Center in Leiden. For the *Flora of Singapore* project, she contributed to the family Poaceae, which was published in volume 7 (Poales) in October 2019.



(Photo credit: Lim Jun Ying)

Yao Tze Leong visited the SING Herbarium from 15 March to 2 April 2020 to study specimens of *Garcinia* (Guttiferae) and *Aristolochiaceae*. Yao is a Research Officer (Forest Ecologist) at the Forest Research Institute Malaysia and is currently doing a PhD on *Garcinia*. Prior to this, during his early years at FRIM,

Yao contributed to the writing of various plant family accounts for the *Flora of Peninsular Malaysia*. While in Singapore, Yao also presented a talk entitled 'The Origin of Domesticated Mangosteen', a collaboration with Nanyang Technological University. He will be contributing to the *Aristolochiaceae* account for the *Flora of Singapore* project.

Bazilah Ibrahim
Herbarium

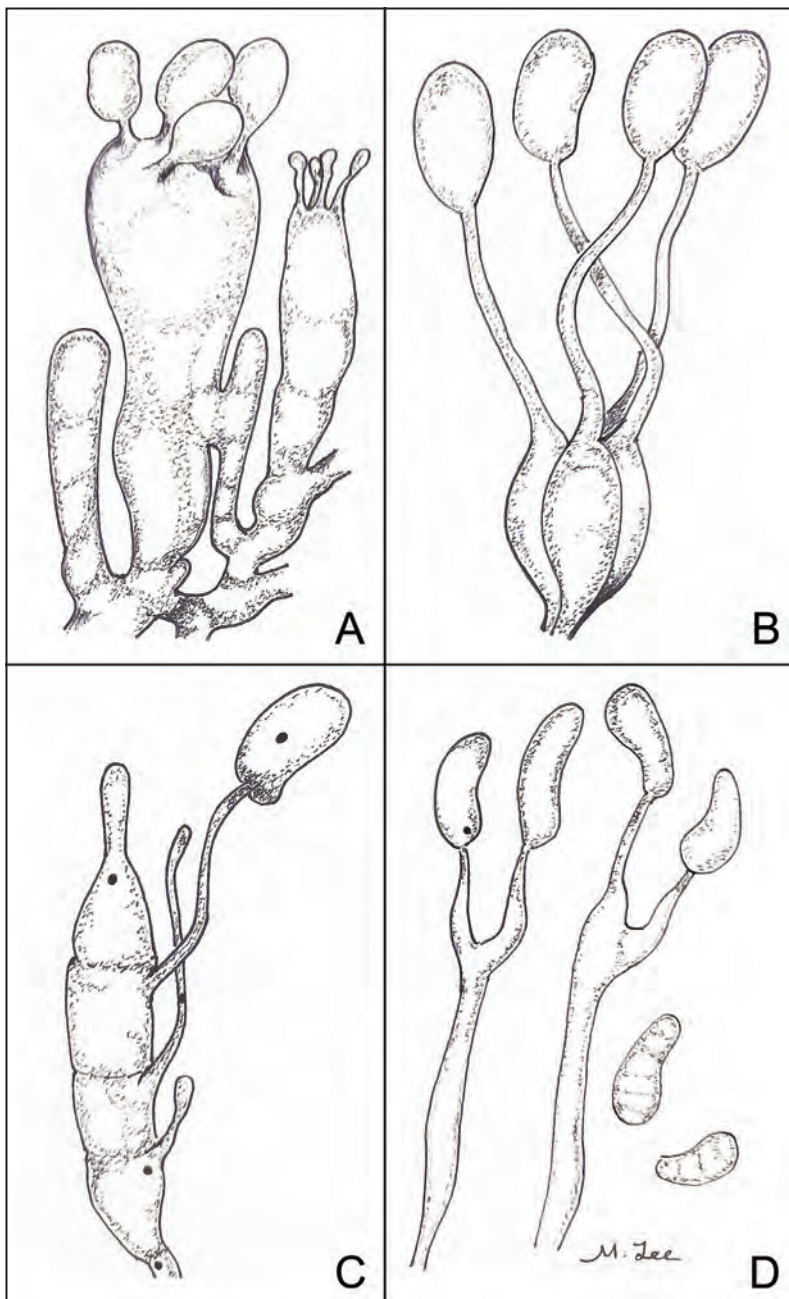


Jelly fungus – doesn't matter if you're black or white!

The jellies of this earth comprise a superficial group of fungi, like some of the other categories touched upon in previous articles in this series. They are so-called jellies because they have a rubbery or gelatinous consistency when fresh but are not related and in fact come from a few different orders in the fungal kingdom. The Auriculariales, Dacrymycetales and Tremellales are known from our part of the globe and they come in an array of colours, from yellow, pink, purple to

black, and white (translucent). While the Auriculariales and Dacrymycetales are prolific wood-decomposing fungi, most of the Tremellales are parasites on other living fungi.

Although macroscopic identification can sometimes be tricky, classification of the jelly fungi is comparatively easy under the microscope. The orders can be distinguished by their basidia (spore-bearing structures) found on the fruiting bodies.



- A. The majority of **Basidiomycetes**, including the gilled mushrooms, polypores, boletes and gasteromycetes, develop basidia without septa (walls). Known as holobasidia, they are club-shaped and produce four basidiospores which are held on by structures called sterigmata.
- B. When viewed from above, basidia in the **Tremellales** are cruciate, or cross-shaped. They develop longitudinally septate basidia, parallel to the direction of growth. The spores are attached by long sterigmata.
- C. The **Auriculariales** develop transversely septate basidia, perpendicular to the direction of growth. The septa are usually not easily visible under the microscope.
- D. The basidia of **Dacrymycetales** are aseptate (without walls) and have the form of tuning forks. They are surrounded by a gelatinous matrix and require diligent work to tease them out by chopping and squashing small samples of the fruiting body on a slide prior to microscopic identification. The fruiting body used can be from either a fresh specimen or a rehydrated sample.

Basidia types. (Drawn by Maria Lee)

Jelly fungi from the order Ariculariales



(Left) *Auricularia* cf. *fuscossuccinea* from Bukit Timah Nature Reserve, and (right) an undetermined species of *Auricularia* from the Central Catchment Nature Reserve.



(Left) Side view and (right) the underside of *Pseudohydnum gelatinosum*, a jelly tongue fungus from Scotland.



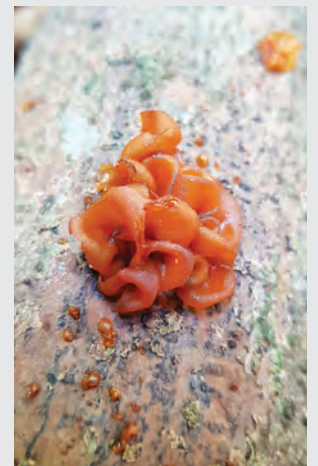
Auricularia from Mulu National Park, Malaysia. (Far left and centre) Top view and the underside of *Auricularia* cf. *delicata*. (Left) An as-yet to be determined species of *Auricularia*.

Jelly fungi from the order Dacrymycetales



(Left) *Calocera viscosa*, the Staghorn Jelly Fungus, from Scotland, and (right) *Dacryopinax spathularia*, the Sweet Osmanthus Ear, from the Central Catchment Nature Reserve.

Jelly fungi from the order Tremellales



(Left) *Tremella fuciformis*, the Snow Fungus, from Jacob Ballas Children's Garden, and (right) *Tremella* cf. *mesenterica*, Witches' Butter, from the Central Catchment Nature Reserve. (Photo credits: Leong Fong Feng, Chan Wai Yeng)



Notable jelly fungi used in Singapore



Known locally as (left) *bai-mu-er* and (right) *hei-mu-er*, many Singaporeans are familiar with these two jelly fungi. They are shown here at a grocer's in the heartlands.

The snow fungus

The *bai-mu-er* (白木耳) or white wood-ear is also known as snow fungus (雪耳), snow ear or silver ear fungus (银耳), and its scientific name is *Tremella fuciformis*. According to literature, it has a host of medicinal benefits such as antioxidant and anti-tumour activities and has been shown to improve memory in rats. In Traditional Chinese Medicine (TCM), the white wood-ear is used to treat a lack of energy, shortness of breath, paleness, low immune system function, dry skin, eczema, dry cough and dry throat. Hence *bai-mu-er* is known to nourish yin energies and clear heat, thereby alleviating these symptoms.

Snow fungus is commonly cooked in sweet soups with pear, papaya or ginko. You can sometimes even find it in *cheng-tng*!

The black fungus

The *hei-mu-er* (黑木耳), black wood-ear or black fungus is taxonomically more complicated than the snow fungus. What was collected, cultivated, sold and known as *hei-mu-er* in China and thought to be *Auricularia auricula-judae* is in fact a complex of species. The commonly cultivated species was found not to be *Auricularia auricula-judae* (a species first described from Europe) but a species unknown to science at the time. It was then promptly given the epithet *heimuer* and hence it is *Auricularia heimuer*.

A friend who operates a TCM medical hall tells me of two types of black fungus. The smaller one, called *hei-mu-er*, is generally the same colour throughout, a gray to dark gray when dry, and is likely *Auricularia heimuer*. The larger one, known as *hei-bai-mu-er*, is black on one side, whitish and



Hei-bai-mu-er from a local TCM medical hall.
(Photo credit: Foo Ju Fang)

visibly hairy on the other side, and likely to be *Auricularia villosa*. While the primary purpose of the smaller one is to enrich the blood, the larger one is used to promote blood circulation.

Modern medical research has shown that extracts of the black fungus have anti-ageing properties and are effective in lowering blood sugar, improving immunity, and preventing and treating various cancers. The black wood-ear is often used to add texture to dishes such as vegetable stir-fries and salads. It must be hydrated before using though!

No matter whether they're black or white, yellow, pink or purple, mushrooms in general provide vitamin D, and have a host of minerals and trace elements such as magnesium, selenium, folate and zinc. Not only that, they are low in calories and cholesterol, and fat free.

Just an advisory not to forage for mushrooms in Singapore. Not only will this protect our native biodiversity, many mushrooms are poisonous and difficult to identify correctly – you'll live longer getting them from the supermarket or your friendly neighbourhood grocer!

Serena Lee
Herbarium

Maria Lee
Former NUS Research Associate in Mycology

All images by Serena Lee, unless otherwise stated



Colour your vegetable garden with ornamental underground edibles

Vegetable gardens can be visually monotonous compared to ornamental gardens which tend to have a variety of shapes, colours and textures. A good way to break this monotony is to inject colour by including ornamental vegetables. Put simply, ornamental vegetables are colourful versions of familiar edible plants, with their most visually interesting trait being their foliage.

Incidentally, quite a number of plants that yield edible underground storage organs have colourful counterparts, including Taro (*Colocasia esculenta*), Sweet Potato (*Ipomoea batatas*), Tannia (*Xanthosoma sagittifolium*), Cassava (*Manihot esculenta*) and Arrowroot (*Maranta arundinacea*). Ornamental cultivars of these species are edible but may not taste as good as conventional ones that have been selected and grown for food.

Taro, Sweet Potato, Tannia, Cassava and Arrowroot are suitable for planting in Singapore as they thrive in our hot and humid climate. In the garden, they can be planted in groups to serve as visual focal points that stand out from a largely green background. A word of advice is to not overuse them though; some of these ornamental vegetables have brightly coloured leaves that scream for attention and may detract from other plants in the garden.

Taro

Recently, due to the surge in popularity of aroids among plant lovers, ornamental Taros have come into the limelight. Numerous cultivars exist that feature different foliage colours and patterns. They thrive in humid, outdoor locations with filtered sunlight, and can be



Ornamental cultivars of *Colocasia esculenta* (Taro) are very popular right now.

From left to right: 'Mojito', 'Illustris' and 'Nancy's Revenge'. (Photo credits: Vicky Lim Yen Ngoh, Lily Chen, Vicky Lim Yen Ngoh; courtesy of NParks Flora & Fauna Web)

planted in a moist spot near the edge of a pond or in a water-tight container. These ornamentals may produce either suckers at the base or runners, and these can be used to propagate new plants.

Cassava

Ornamental cultivars of Cassava have brightly coloured leaves that

are variegated in yellow or white. There are also cultivars with different leaf shapes which can confer some contrast in textures. Cassava is best grown in a well-draining spot outdoors in direct sun, and once established, can be quite drought-tolerant. New plants can be propagated by rooting woody stem-cuttings.

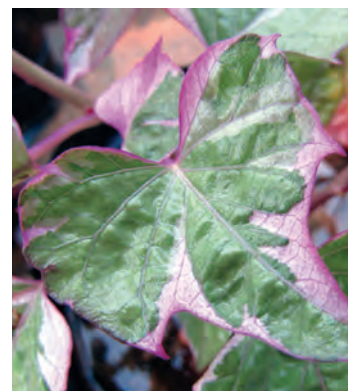


There are two variegated ornamental cultivars of *Manihot esculenta* (Cassava) in Singapore. Both feature attractive leaves that can add a splash of colour to an edible garden.



Sweet Potato

Sweet Potatoes are generally grown as groundcovers in places where the trailing stems are allowed to sprawl. Ornamental cultivars offer a range of leaf shapes and colours, and young plants are occasionally used to spill over the edge of container gardens to soften their edges. Their stems can climb by twining and can be trained onto a structure like a tepee. These plants do best in a sunny spot outdoors and need to be grown in moist, well-draining soil. They are easily propagated by stem-cuttings.



Three commonly seen ornamental cultivars of *Ipomoea batatas* (Sweet Potato). From left to right: 'Black Heart', 'Margarita' and 'Pink Frost'. (Photo credits: Jane Li, Patricia Yap, Vicky Lim Yen Nghoh; courtesy of NParks Flora & Fauna Web)

Arrowroot

Belonging to the Prayer Plant family (Marantaceae), Arrowroot produces tuberous starchy roots which are well-known as a source of easily digestible flour that is used in baby food. The ornamental version of this plant has variegated leaves with streaks of white. It adopts a clumping growth habit and can be propagated via division. Unlike most other members of its family, Arrowroot grows best under direct sunlight and should be planted in a moisture-retaining soil.



The variegated *Maranta arundinacea* (Arrowroot) has splashes of white on its leaves which add to its appeal. The underground tuberous roots can be harvested and eaten. (Photo credit: Wilson Wong)

Tannia

Tannia belongs to the same botanical family as Taro (Araceae). The two plants resemble each other morphologically and are easily confused. However, one can differentiate them based on the appearance of their leaves. There is an ornamental cultivar of Tannia known by the name of 'Lime Zinger', which features bold, chartreuse, shield-shaped leaves. Tannia should be grown under the same conditions as Taro and can be propagated in the same manner.



***Xanthosoma sagittifolium* 'Lime Zinger' features brightly coloured leaves and due to the large size of the plant and its leaves, it makes a striking focal point in the garden. (Photo credit: Wilson Wong)**

Wilson Wong
Jurong Lake Gardens



Measuring the positive impacts of the Gardens' educational programmes for schools

As COVID-19 wreaks havoc on Singapore and the whole world, we are faced with unprecedented challenges in education. As a result, we have been reviewing our operations, re-evaluating the approaches and impacts of our programmes, and reaching out to our community in uncharted and novel ways. Looking at the situation positively, the need for social distancing and the requirement for staff to work from home created a window of opportunity for us to thoroughly review our educational programmes.

Our pedagogical approach

The Gardens' educational team practices a pedagogical approach that is closely

aligned with that of the Ministry of Education (MOE) for preschools, primary and secondary schools. We use an integrated approach to facilitate students' holistic learning, and depending on the needs of the school, we customise our programmes to make them relevant and meaningful for the students.

For preschools, we tie our pedagogical approach closely with MOE's Nurturing Early Learners (NEL) Framework. There are six learning areas in the NEL Framework which focus on the learning and development of pre-schoolers: 1) aesthetics and creative expression, 2) discovery of the world, 3) language and literacy, 4) motor skills development, 5) numeracy, and 6) social and emotional

development. When designing programmes for early learners, we are mindful to adhere to and address these six defined learning areas.

For older children in primary and secondary school, our pedagogical approach ties closely with MOE's Science and Geography syllabus. An inquiry-based approach is primarily MOE's teaching methodology, where inquiry is grounded in knowledge, issues and questions that relate to the roles played by science and geographic issues in our daily life, society and the environment.

Thus, we build on MOE's focus on equipping students of all ages with competencies and scientific literacy for the 21st century by incorporating it along with the Gardens' mission of 'Connecting Plants and People'. We aim for our educational programmes to stay relevant, supplement the learning objectives of schools, and support students' learning – from fostering their awareness, exploration and acquisition of knowledge, to applying these qualities to their daily lives.

Evaluating impact

Feedback from participants of our programmes has always been very encouraging, and we have observed personal growth in older students participating in our intensive and multiple-session programmes. The fact that we also have schools returning to take up the same programmes year after year speaks volumes about their success. So, we can confidently say that we have a positive impact on our young visitors from schools. The question facing us then, is how do we measure this impact?

To answer this question, we first defined how we see impact in terms of environmental education. We

	1 point	2 points	3 points	4 points
1. Number of programme sessions	1 session	2 sessions	3 sessions	> 3 sessions
2. Guide : Student ratio	1 : 30 or more	1 : 21–30	1 : 11–20	1 : 10 or less
3. Reflection time allowed?		Yes		
4. Small group activity included?		Yes		
5. Opportunity for students to collect, analyse and evaluate data?		Yes		
6. Opportunity for students to present observations and findings?		Yes		
7. Level of teaching to learning (delivery of programme)	Students only observe	Students observe and raise questions to the level of their own self-awareness	After they learn and understand content, students present and communicate content to a target audience	Students apply their understanding, and form a reasonable and logical argument to communicate their understanding
8. Level of personal (teaching) interaction between guide and students	Minimal inquiry-based lessons – driven by the guide with a minimal exchange of ideas	Some inquiry-based lessons – driven by the guide with some exchange of ideas	More inquiry-based lessons – driven by the guide with an exchange of ideas; students prompted to ask questions	Full inquiry-based lessons – driven by students' active thinking and reasoning; guide/trainer takes on role of facilitator
9. Environmental messaging included?		Included, not covered in-depth		Covered in-depth

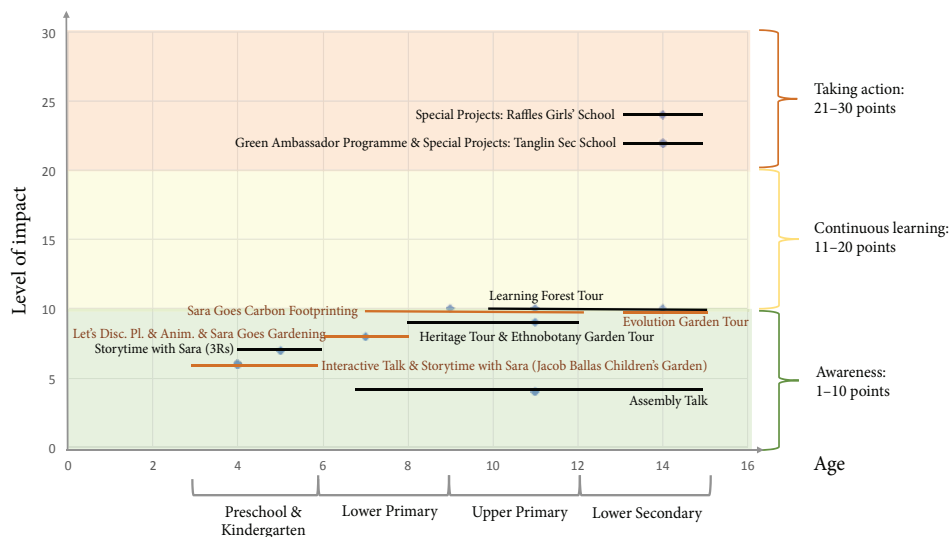
Rubric developed by the Gardens' education team, with nine areas of measurement to evaluate the impact of our environmental education programmes for schools.



Areas of Measurement	Preschool & Kindergarten				Lower Primary				Upper Primary (10–12 year olds)			Lower Secondary (13–15 year olds)			
	Interactive Talk – Dramatisation (3–6 y.o.)	Storytime with Sara – Jacob Ballas Children's Garden (3–6 y.o.)	Storytime with Sara – 3Rs (4–6 y.o.)	Sara Goes to the Supermarket Garden (4–6 y.o.)	Let's Discover Plants & Animals (7–8 y.o.)	Sara Goes Gardening (7–9 y.o.)	Sara Goes Carbon Footprinting (7–12 y.o.)	Assembly Talk (7–15 y.o.)	Heritage Tour	Ethno-botany Garden Tour	Learning Forest Tour	Evolution Garden Tour	Green Ambassador Programme (Girl Guides)	Special Project: Tanglin Sec School	Special Project: Raffles Girls' School
1. Number of programme sessions	1	1	1	1	1	1	1	1	1	1	1	1	4	4	4
2. Guide : Student ratio	2	2	2	2	2	2	2	1	2	2	2	2	4	4	4
3. Reflection time	0	0	0	0	0	0	2	0	2	2	2	2	2	2	2
4. Small group activity	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2
5. Students collect, analyse and evaluate data	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2
6. Students present observations and findings	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2
7. Level of teaching to learning (delivery of programme)	1	1	2	2	2	2	2	1	2	2	2	2	3	3	4
8. Level of interaction between guide and students	2	2	2	2	3	3	3	1	2	2	3	3	3	3	4
TOTAL SCORES	6	6	7	7	8	8	10	4	9	9	10	10	22	22	24

KEY TO SCORES: 1–10 = Awareness 11–20 = Continuous learning 21–30 = Taking action

Scores of 15 existing representative programmes delivered to different academic levels. The ninth area of environmental messaging is not currently covered in-depth as part of our programmes, but we will be incorporating this area moving forward.



Level of impact of our environmental education programmes versus age. The dot in the centre of each horizontal bar shows the average age of participants within the programme.

determined three different levels. The first level is creating awareness about nature and the environment, the second is encouraging continuous learning about these subjects, and the third level is inspiring students to take action. Next, we developed a rubric comprising nine different areas of measurement to evaluate the impact of our programmes with respect to our three levels. These are 1) the number of sessions in the programme, 2) the guide-

to-student ratio, 3) whether the programme allows for reflection time, 4) whether it incorporates small group activities, 5) if the students are given the opportunity to collect, analyse and evaluate data, 6) whether they present their observations and findings to others, 7) how the programme is delivered, 8) the level of interaction between the guide and students, and 9) the incorporation of environmental education messaging.

We then chose 15 representative and popular programmes targeted at different academic levels and scored them according to our areas of measurement. We broke down the scoring into three separate bands according to our defined levels of impact, with scores of 1 to 10 within the first level of creating awareness about nature and the environment, scores of 11 to 20 falling within our second level of encouraging continuous learning, and scores of 21 to 30 at our third level of inspiring students to take action.

For our youngest participants, our programmes generally aim to create an awareness about nature and the environment, and we can see from our scores that these programmes are doing well in this respect. Of the programmes targeted at preschool, kindergarten and lower primary students, 'Sara goes Carbon Footprinting' achieves the highest score based on our rubric. This is not surprising as this programme goes in-depth into environmental issues and we work on convincing students to take action. At the other end of the spectrum are the assembly talks for primary and secondary students, which score the lowest because they allow for limited interaction, especially when

the facilitator is addressing hundreds of students at one time. However, despite their lower score, we consider the assembly talks successful because they generate interest about nature and the environment and consistently receive positive feedback from teachers and students.

Our programmes for upper primary students, such as the tours of various areas of the Gardens, scored slightly higher than those for the younger students. Our programmes targeting lower secondary levels scored the highest because they engage the students more deeply, testing them on what they know, encouraging them to reflect on what they've learnt, and pushing them to apply this knowledge. A good example is our Green Ambassador programme, which is carried out over multiple sessions in partnership with girl guides from various schools. We have personally observed participants who are hesitant to speak to peers outside of their own school but from the same ambassador training group blossom to become bright and confident young adults. On completion of the programme, they were willing to approach total strangers to guide them around the Gardens. Other successful programmes were special projects with students from Tanglin Secondary School, who served as guides for the launch of the Heritage Garden in 2016 and the launch of the Learning Forest in 2017, and from Raffles Girls' School, who initiated project DeVice in 2019, which aims to encourage children to spend more time outdoors, enjoy nature and be less dependent on electronic devices.

Conclusions thus far

All of our educational programmes increase awareness about nature and the environment, and often build on existing knowledge that the students have. The programmes that achieve the highest impact relative to our three defined levels are those that are run over multiple sessions, with higher investments of time, effort and manpower from the Gardens' education team. From the feedback received from previous cohorts of Green Ambassadors and students who have participated in our special projects, we know for a fact that these manpower- and content-

intensive programmes have a significant impact on the participants, motivating them to want to learn more and take action.

Strategies for improvement

The schools that visit the Gardens have their own objectives and are also constrained by the amount of time that they can spend with us; often, there is little that we can do to change programme content, duration and structure. For instance, due to the limited time that we have with each school group, it is usually not possible to divide larger school groups into smaller groups for more focussed discussions.

So, what can we do? We can tweak our programme delivery and seed stronger environmental messages into all of our programmes. We can ask the students more questions to get them thinking and challenge them to analyse and make connections about organisms and systems in the environment. We can also allow time for reflection on what the students have observed and learnt through the programme.

To allow for continuous improvement of our programmes we will gauge immediate impacts through polling and asking students questions about their experience. Teachers and accompanying parents will be encouraged to complete a digital evaluation form, with questions



Students looking for small insects, collecting data and making observations in small groups while participating in 'Let's Discover Plants & Animals'. (Photo credit: Winnie Wong)



Guides use an inquiry-based approach to interact with students, asking questions and challenging ideas and thinking. Here, one of our guides is leading a training session at the National Orchid Garden. (Photo credit: Janice Yau)



A student from Tanglin Secondary School giving a presentation to an audience during a training session leading up to the launch of the Learning Forest in 2017.

(Photo credit: Janice Yau)



Students reflecting on a lesson for the day and fine-tuning scripts for a presentation in preparation for the opening of the Jacob Ballas Children's Garden extension in 2017.

(Photo credit: Janice Yau)

focussed on programme design and relevance of content, feedback about the guides and facilitators, overall rating of the programme, if they would recommend the programme to their colleagues or friends, and areas for improvement.

We will also aim to make it easy for teachers to do follow-ups with their students when back in the classroom. We are working on 'when back in

school' packages that will include an activity sheet for students to reinforce their learning within a few days of their visit to the Gardens, articles for further reading, and lists of resources for teachers, parents and the students to deepen their understanding of the subject matter. Lastly, the package will include a list of additional fun things to do – activities which the teachers can carry out with their students one to two months later. To gauge if we made a

longer-term impact, we will touch base with the teachers further down the road for feedback.

With these improvements we hope to 'level up' a good number of our programmes to push students beyond awareness about nature and the environment to becoming continuous learners. We aim to create sustained interest in the environment and concern for pressing global issues such as climate change and food insecurity, and we hope to inculcate environmental stewardship amongst even our youngest participants. Some programmes, such as the assembly talks, will remain focussed on creating awareness as a good starting point to engage students who may not know about or even be interested in environmental issues to begin with.

Future programmes

One new programme that we would like to implement soon is a training workshop for lower secondary students at the Seed Bank. This will add another multiple-session, hands-on and intensive programme to our repertoire. As with all new school programmes that we design from here on out, we assessed this programme using our rubric for environmental education impact, and it scores 23 points.

Over recent months, when measures were implemented to limit the spread of COVID-19 in Singapore, it became obvious that digital platforms now play an essential role in sharing knowledge. Social distancing has become the new norm, directly impacting the way traditional educational programmes are conducted, not just in the Gardens but around the world. To stay relevant while we continue to fight the pandemic, we have virtual assembly talks in the pipeline focussing on the Gardens' heritage and biodiversity.

Do look out for future instalments to learn about our new and improved programmes, which we hope will bring about positive changes in behaviour and attitudes among children towards nature and the environment!

Janice Yau
Winnie Wong
Education Branch



Miniature durians – not!

During the challenging days of the Circuit Breaker when human activity was limited to prevent the spread of COVID-19 in Singapore, the Gardens stayed abuzz through its plant life. The weather for the most part was good before and during this period, which ensured the plant collections continued to grow, flower and fruit, undisturbed by human intervention. In the Learning Forest, a collection of plants commonly known as pandans began flowering sporadically. Among them, the infructescences, or fruiting heads, of a species known as *Benstonea affinis* stood out.

The pandans belong to the family Pandanaceae which contains five genera, namely *Pandanus*, *Sararanga*, *Freycinetia*, *Martellidendron* and *Benstonea*. The last two of these were formerly placed in the genus *Pandanus* but were recognised as distinct genera based on DNA sequencing a few years back. The genus *Benstonea* is named in honour of Benjamin Clemens Stone (1933–1994), a British-American botanist who had contributed immensely to the study of the flora of Southeast

Asia and Oceania as well as to the taxonomy of the Pandanaceae. Stone was the leading authority on the family for several decades until his untimely death at the age of 61 from a heart attack while working in the herbarium of the Philippines National Museum. His work on the Pandanaceae still remains fundamental to the study of this group of plants.

Benstonea affinis, also known by its synonym *Pandanus affinis*, is commonly known in Malay as Mengkuang Bunga or Pandan Ikan. It can be found in Vietnam, Peninsular Malaysia, Singapore, Sumatra, Borneo and the Philippines, where it occurs in freshwater swamps, peat swamps and along watercourses, from sea level to altitudes of 500 m. It has also been found on the edges of lowland rainforests. It grows as a short-stemmed large shrub or small tree, and is dioecious, meaning that it produces female and male reproductive structures on different plants. It can reach a height of around 3 m, with prop roots up to 60 cm long from the stem base. The leaves are ligulate, or strap-

shaped, and up to 2 m in length with thorns along the margins. The thorns point obliquely forward at the base and are rather large, about 2.5 mm in length, although they become smaller as one moves towards the tip of the leaf. The leaf's mid-rib is also prickly, but with smaller thorns that tend to disappear higher up the mid-rib. The inflorescences are borne on short side-branches. The male inflorescence is usually spiked, and the female inflorescence is spiny and globular in shape, retaining this form as it develops into an aggregate fruit. An erect stem holds three to nine flower heads which are typically crowded together at the apex. The infructescences are spiny and ripen from green to a lovely shade of orange-brown. They are about 6 cm in diameter and look very much like miniature durians.

Benstonea affinis and several other *Pandanus* species are important plants in the tropics. For example, in Peninsular Malaysia, leaf decoctions of *Benstonea affinis* and *Pandanus klossii*, and probably other *Pandanus* species, are administered after childbirth to promote the good health of the mother. Other examples are *Pandanus amaryllifolius*, or the Fragrant Pandan, which is used to flavour and colour food, and *Pandanus conoideus*, or the Buah Merah, which provides edible fruits. Other species, such as *Benstonea atropurpurea* (formerly *Pandanus atropurpureus*), commonly known as Mengkuang, are used in weaving items such as mats, hats and baskets.

Benstonea affinis fits nicely into natural landscapes such as at the Learning Forest. On your next visit, keep an eye out for its bright orange-brown durian-like fruits amidst the other pandans.



The Keppel Discovery Wetlands in the Learning Forest showcases plants that are typical of freshwater forest wetland habitats in the region. The pandan collection is shown in the foreground.

Nura Abdul Karim
Research and Conservation



(Clockwise from top left) Infructescences of *Benstonea affinis* in various stages of maturation. (Photo credits: Amanda Loh)



The Art of Birding – an exhibition on bird appreciation through art



Kingfishers illustrated by Frank Jarvis, from the book *Birds of Singapore*. From top to bottom, a White-throated Kingfisher (*Halcyon smyrnensis*), Collared Kingfisher (*Todiramphus chloris*) and Black-capped Kingfisher (*Halcyon pileata*).

The colourful plumage, melodious songs and graceful flight of birds have captivated and inspired people for many thousands of years. Birds have been a feature of human culture and creativity from the very outset – the first drawing of a bird (an owl) was discovered in a cave in France dating back to the Paleolithic Age. Birds continue to be celebrated in art, music, poetry and literature in all countries, cultures and societies. The Art of Birding exhibition, held in the CDL Green Gallery since November 2019, shows the vibrant world of our feathered friends through the eyes of birders and artists in Singapore.

In particular, the exhibition highlights the keen observations of writer Christopher Hails and artist Frank Jarvis, who collaborated to publish *Birds of Singapore*, one of the first pictorial guides to Singapore's birds. Chris weaved his scientific knowledge into the text, while Frank worked his artistic hand into rendering life-like illustrations of 131 birds in the book. *Birds of Singapore* is a seminal volume in local biodiversity guidebooks. It was published over 30 years ago when Singapore was first embarking on its journey to integrate nature into the urban landscape. The informative descriptions of the individual bird species, accompanied by Frank's beautiful illustrations, provide readers a glimpse of the wonders of birding. Thirty years later, it is not only an important book in igniting a passion for bird-watching among many generations of Singaporeans, but also remains a valued part of any local birder's library collection.

Despite its small size, Singapore's diverse habitats and well-connected greenery supports a rich variety of birds, with over 400 species recorded to date. More than 110 of Frank's observations and illustrations of Singapore's native birds can be found in the gallery, categorised by the habitats in which they occur. Our local parks and gardens, such as the Singapore Botanic Gardens, are a haven for a variety of resident parkland and forest birds. Common birds found in these urban green spaces are those that are opportunistic in nature, being able to adapt to more urban habitats, such



A White-breasted Waterhen (*Amaurornis phoenicurus*) illustrated by Frank Jarvis.



as the Brown-throated Sunbird (*Anthreptes malacensis*) and the Collared Kingfisher (*Todiramphus chloris*). The latter is a conspicuous and vocal bird that is common along coasts but is also often encountered in gardens. It usually sits on an exposed perch before swooping down to the ground to catch crabs, worms, large insects and lizards.

Freshwater wetlands are characterised by waterlogged conditions with low salinity levels. These conditions are conducive for plant growth and provide the perfect backdrop for a rich variety of plants and animals to flourish. Birdlife is abundant, ranging from soaring fish eagles surveying for prey to rails skulking in the dense vegetation along the water's edge. Many waterbirds like the White-breasted Waterhen (*Amaurornis phoenicurus*) have long legs to wade through the water easily. When confronted with danger, their long legs also allow them to readily make a dash for the nearest cover.

The secondary forests in Singapore support different vegetation layers and hence a large diversity of birds of different shapes, sizes and colours, depending on where they live in the forest. Birds that live in the canopy like the Chestnut-bellied Malkoha (*Phaenicophaeus sumatranus*) have green and grey in their plumage, which provides camouflage as they move through the trees. Many forest birds also show sexual dimorphism, with males being much more colourful than the drab females. This is particularly apparent among many sunbirds and flowerpeckers.

Dominated by tall grasses and a scattering of shrubs and trees, grasslands are one of the most common habitats throughout the world. These wide, open spaces are home to many species of birds, including a few that have adapted to feeding on grass seeds. Some of the most easily recognised grassland birds include the White-headed Munia (*Lonchura maja*) and Chestnut Munia (*Lonchura atricapilla*). These birds travel in vocal flocks and primarily feed on grass seeds, which they crack open with their robust bills. Many other species skulk in the



A Brown-throated Sunbird (*Anthreptes malacensis*). (Photo credit: Dillen Ng)



A Chestnut-bellied Malkoha (*Phaenicophaeus sumatranus*). (Photo credit: Dillen Ng)



A Daurian Redstart (*Phoenicurus aureoreus*). (Photo credit: Dillen Ng)



A Japanese Tit (*Parus minor*). (Photo credit: Dillen Ng)

dense vegetation like the migratory Oriental Reed Warbler (*Acrocephalus orientalis*), feeding on insects and other small animals.

Yet another group of birds can be found feeding on intertidal mudflats, a type of coastal habitat that is found at river mouths or along shorelines and are exposed at low tide. Rich in organic matter, mudflats support many organisms like marine worms, crabs and other shellfish. These habitats are particularly important for migratory shorebirds, who rely on these rich food sources to fuel their epic migratory journeys.

Singapore is situated along the East Asian-Australasian Flyway – a route stretching practically from northern Russia to New Zealand, used by migratory shorebirds on their annual migration. These shorebirds make various stopovers on coastal mudflats to rest and feed on their way down to their wintering grounds located in Southeast Asia, Australia and New Zealand.

Besides coastal habitats, numerous migratory bird species can also be spotted in our primary and secondary forest habitats between the months of September and April

in Singapore. The 2019–2020 season in particular saw a whole host of important records for Singapore, with many vagrants and overshooting migrants making their way to our island. Some examples include the first records of birds such as the Fairy Pitta (*Pitta nympha*, Central Catchment Nature Reserve), Taiga Flycatcher (*Ficedula albicilla*, Singapore Botanic Gardens), Shikra (*Accipiter badius*, Central Catchment Nature Reserve) and White-cheeked Starling (*Spodiopsar cinereus*, Seletar). Other fascinating birds that turned up include the Daurian Redstart (*Phoenicurus aureoreus*), Japanese Tit (*Parus minor*) and Dusky Warbler (*Phylloscopus fuscatus*) – our last documented sighting of the warbler was back in 1995!

Singapore's founding Prime Minister, Lee Kuan Yew, envisioned a Garden City idea for our nation in 1967, and took measured steps to bring it to fruition. The Garden City vision aimed to distinguish Singapore from other countries and also make greenery accessible to all Singaporeans. Biodiversity was incorporated into the urban landscape through a big greening movement that continues today. Millions of trees were planted to provide shade and soften the concrete landscape. In addition, a network of parks and park connectors was also developed for recreation and ecological connectivity. Today, this network has created a sustainable urban ecosystem for nature and people to thrive. The impressive number of bird species in Singapore, which has resulted in a growing community of bird-watchers, bears testament to our successful journey towards a City in Nature.

The Art of Birding exhibition is on until 11 October 2020. The CDL Green Gallery is open daily from 9am until 6pm, except for the last Tuesday of each month. Admission is free, so do stop by on your next visit to the Gardens.

Sheryl Koh
Low Bing Wen
Dillen Ng
National Biodiversity Centre



Revisiting Singapore – the Asia Pacific Biodiversity Observation Network

In February 2020, Professor Tetsukazu Yahara, co-chair of the Asia Pacific Biodiversity Observation Network (AP BON) and Director of the Center for Asian Conservation Ecology at Kyushu University, and Mr Norihiro Matsushima, Director of OMC Incorporated, Japan, were hosted by staff of the Gardens and other divisions of the National Parks Board (NParks).

AP BON was established in Nagoya, Japan, in 2009 as a regional network related to the Group on Earth Observations Biodiversity Observation Network (GEO BON), which covers most countries in the Asia Pacific region. Over the years, AP BON has been working to identify threats to biodiversity and the anthropogenic actions that may hamper achieving the UN Sustainable Development Goals. AP BON observes biodiversity on three levels – through remote sensing, research on ecological processes, and

research on species and genetics. AP BON aims to link the findings from each level of observation with the development of appropriate conservation policies. It also organises annual workshops to share information and knowledge on various aspects of biodiversity conservation.

Professor Yahara is a renowned ecologist and botanist. He documented some of the achievements and challenges of AP BON within the Asia Pacific region in the book *Integrative Observations and Assessments*, which was published in 2012, touching on the biodiversity conservation efforts of Singapore and other Southeast Asian countries at the time. Professor Yahara's recent visit was part of an effort to learn how conservation efforts have progressed since 2012, and he was particularly interested in understanding the holistic approach and new initiatives that Singapore has put in place to protect our biodiversity.

During his visit, Professor Yahara presented some of the recent observations made by AP BON on biodiversity and conservation efforts around the region, and encouraged greater participation from the various agencies in Singapore and other parts of Southeast Asia in order to better gauge the state of the region's biodiversity and ecosystems. Senior staff from the Gardens and other divisions of NParks also gave a presentation on our various conservation initiatives. This was followed by a dialogue during which Professor Yahara voiced his appreciation for the comprehensive update on our research and conservation efforts in Singapore.

Apart from the presentations and discussion, Professor Yahara and Mr Matsushima toured the Gardens' herbarium, micropropagation laboratory, Seed Bank and Ethnobotany Museum. They also visited Bukit Timah Nature Reserve where they were met by NParks' staff and briefed by Dr Shawn Lum from the Asian School of the Environment at Nanyang Technological University (NTU) on a 2-ha research plot within the reserve. Known as the Bukit Timah Forest Dynamic Plot, it was initiated in 1992 by NTU, the Smithsonian Tropical Research Institute/ForestGEO in collaboration with NParks. The first census began in 1993 on this isolated patch of forest, and it has since provided an excellent opportunity to study the impacts of forest fragmentation and dynamics. The plot has also allowed researchers to investigate the effects of faunal loss in the forest over time.

The visit by Professor Yahara and Mr Matsushima enabled us to strengthen our ties with AP BON, share what we are doing here in Singapore toward biodiversity conservation, and learn about other conservation efforts being done in the region.

Nura Abdul Karim
Research and Conservation



Professor Yahara being briefed on the Gardens' herbarium collections by Bazilah Mohd Ibrahim. (Photo credit: Dr Nura Abdul Karim)

January–June 2020



H.E. Agustín García-López
Loaeza, Ambassador of Mexico to
Singapore, **Mr Isidro Ortiz**, Third
Secretary, Cultural Affairs and
International Cooperation, and
Mdm Katya García-López

Prof. Alain Fischer, Professor of
Experimental Medicine, Collège de
France in Paris, and **Mr Vincent
Hourcastagnou**, Science and
Technology Officer, Embassy of
France to Singapore

Dr Bill McDonald, Queensland
Herbarium, Australia

Dr Bruce Maslin, Western Australia
Herbarium, Australia

Dr Ed de Vogel, Naturalis
Biodiversity Center, Leiden, The
Netherlands

Dr Elliot Gardner, The Morton
Arboretum, United States of
America

Dr Ivan Savinov, Moscow State
University of Food Production,
Russia

Dr Martin Dančák, Palacky
University, Czech Republic

Dr Michal Hrones, Palacky
University, Czech Republic

Dr Otto Miettinen, Finnish
Museum of Natural History, Finland

Prof. Tetsukazu Yahara, Director of
the Center for Asian Conservation
Ecology at Kyushu University
and co-chair of the Asia Pacific
Biodiversity Observation Network,
and **Mr Norihiro Matsushima**,
Director of OMC Incorporated,
Japan

Dr Thamarat Phutthai, Mahidol
University, Thailand

Mr Yao Tze Leong, Forest Research
Institute Malaysia



(Top) **Otto Miettinen** researching fungi in Singapore in collaboration with **Serena Lee** from the herbarium. (Bottom) **Professor Tetsukazu Yahara**, far right, and **Mr Norihiro Matsuma**, second from right, engaging in a dialogue session with senior staff from various divisions in NParks, including Conservation (**Dr Adrian Loo**), the National Biodiversity Centre (**Lim Liang Jim**), International Biodiversity Conservation (**Hassan Ibrahim**, **Jeremy Woon**) and the Singapore Botanic Gardens (**Dr David Middleton**, **Dr Nura Abdul Karim**).

(Photo credits: **Serena Lee**, **Dr Nura Abdul Karim**)



Drawings of vegetables during the Second World War

In 1939, as World War II broke out in Europe, the Gardens created a demonstration plot which came about due to an increased interest by the public in growing vegetables here in Singapore. The plot was located in the area of today's Ginger Garden, near the current entrance to the Learning Forest. The vegetables were labelled, and a list of varieties which could be grown locally, with instructions on their cultivation and propagation, was displayed on a notice board. Articles about local vegetables were also printed in the magazine of the Malayan Agri-Horticultural Association.

After World War II reached Singapore on 8 December 1941, the vegetable plot was maintained under the Japanese-installed management, and in 1943 it was extended to occupy part of the current Symphony Lake area. Vegetables obtained from Japan were also cultivated and trialled, as well as locally available weeds used as vegetables during times of famine.



(Left) A variety of sweet potato (*Ipomoea batatas*) and (right) a variety of aubergine (*Solanum melongena*).



A ripe fruit of *Solanum macrocarpon*, a species from West Africa that is closely related to the aubergine or brinjal (*Solanum melongena*).

In the Gardens' archives is a collection of about 70 coloured drawings of vegetables that date to this period. Only a few of these are signed, but it is assumed that most if not all of them are the work of Juraimi bin Samsuri, who joined the Gardens as a label printer in 1942 during the Japanese Occupation. After the war, he was appointed as the Gardens' artist because of his talent in drawing, even though he had no formal training in art. Working until his premature death in 1971 (when he was only 48 years old), he produced almost 400 paintings as well as hundreds of line drawings.

We do not know why these coloured drawings were made but it can be assumed that they were used for the identification and documentation of the vegetables that were trialled in the Gardens' demonstration plot.

Michele Rodda
Herbarium