



Special Ecology Feature

Conservation and Reintroduction of Native Orchids in the City in A Garden

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LEFT *Grammatophyllum speciosum* flowered at the Singapore Botanic Gardens.
ABOVE *Spathoglottis plicata* is one of our common native orchids.



ABOVE *Dendrobium crumenatum*—the Pigeon Orchid.

Introduction

The Orchidaceae consists of approximately 20,000 to 25,000 species worldwide; more than 800 orchid species in 120 genera have been recorded in Peninsula Malaysia (Seidenfaden and Wood 1992) and orchids are one of the largest vascular plant families in the world and in Southeast Asia.

Singapore is located in one of the centres of flora diversity in the world with thousands of orchid species. It is situated just north of the equator, off the southern tip of the Malay Peninsula. Consisting of the main island of Singapore and many smaller islands, its total land area is about 700 square kilometres. The whole island consists of lowland, with the highest point at Bukit Timah only reaching a height of 165 metres. With a typical equatorial climate, it experiences uniform temperatures and high humidity throughout the year. Average daily temperatures fluctuate between 25 and 32 degrees centigrade. Annual rainfall is about 2,300 millimetres, with the wettest months being from November to January. Although the country is an urban city, many interesting natural habitats can be found. In the heart of the main island is a primary rainforest and freshwater swamp forest. In addition, some mangroves also remain. The other habitats consist of secondary forests, shrubs, grasslands, urban parks, and fields.

The biological and physical factors within each habitat have created numerous ecological niches for many orchids to thrive. After being released from a mature seed capsule, the airborne orchid seeds eventually settle down in a niche, such as on a tree trunk, on rock or on the ground. Provided with the right physical (e.g., moisture and light) and biological (e.g., the right fungus to infect the seed) conditions, the seed will germinate and grow (Arditti 1992). Numerous ecological niches combined with the right climate account for the large number of orchid species found on the island of Singapore. Unfortunately, many of the natural habitats and the native orchids which thrive there have disappeared due to habitat destruction. A comparison of the habitats on the island 150 years ago with those today showed that most of the mangrove and marshy areas have been replaced by industrial estates

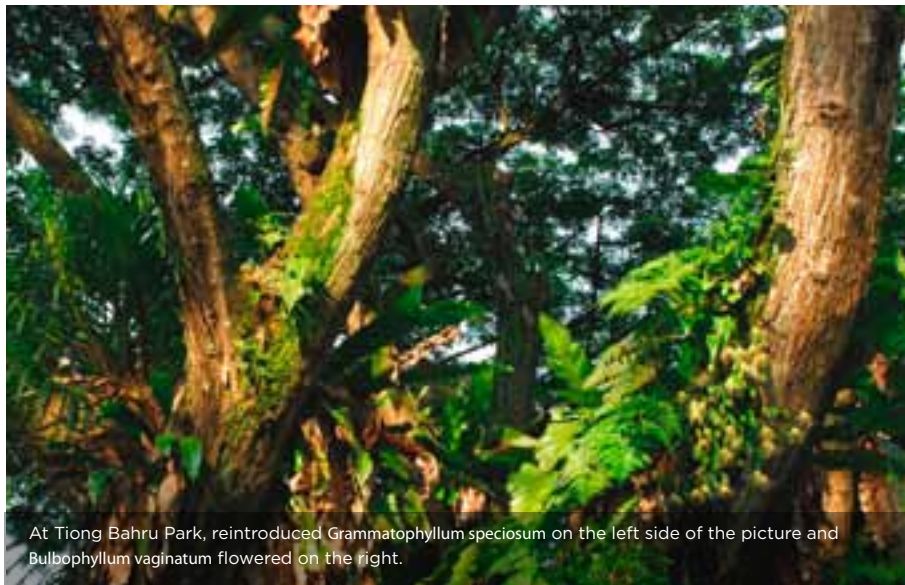
or residential areas. Forest and mangrove areas such as those at Choa Chu Kang, Jurong, Ang Mo Kio, and Serangoon, where native orchids used to thrive, no longer exist. As a result, the native orchids are seriously endangered.

The latest conservation status of the country's native orchids can be found in the Singapore Red Data Book published in 2008 (Davison et al. 2008). Some 226 species of native orchids have been recorded in Singapore. Of these, 178 are considered to be extinct, 40 are critically endangered, one is endangered (*Bulbophyllum vaginatum*), and two are vulnerable (*Vanilla griffithii*, *Bulbophyllum trifolium*). Only five of the native orchids in the Garden City are considered to be common. Four of them are terrestrial (*Arundina graminifolia*, *Bromheadia finlaysonianum*, *Eulophia graminea*, *Spathoglottis plicata*), while the most common of all is the epiphyte *Dendrobium crumenatum*, also known as the Pigeon Orchid.

In terms of habitat, orchids can be divided into two main groups—epiphytes and terrestrials. Epiphytes grow on other plants for support. The term is often used loosely to include plants that grow on rocks and cliffs (the correct term for them should be lithophytes). Epiphytes make up about 75 percent of the orchid species and are limited to tropical and subtropical regions (Dressler 1981, 88-92). In tropical rainforests, the majority of the orchid species are epiphytes. Terrestrial orchids grow in various soils. They are fewer in number, comprising only 25 percent of the total number of species in the family. However, they can be found not only in the tropical and subtropical regions but in temperate zones as well.

Orchid Conservation Programme in Singapore

The orchid conservation programme by the National Parks Board, Singapore (NParks) aims to monitor existing species, explore ways to conserve their germplasm, and increase their numbers through their subsequent reintroduction into appropriate habitats, including roadside trees, parks, and nature areas. Propagation of native species started in



At Tiong Bahru Park, reintroduced *Grammatophyllum speciosum* on the left side of the picture and *Bulbophyllum vaginatum* flowered on the right.

the mid 1990s, and seedlings were introduced in 1999. By 2009, NParks succeeded in propagating and introducing five species of native orchids, namely, *Grammatophyllum speciosum*, *Bulbophyllum vaginatum*, *Bulbophyllum membranaceum*, *Cymbidium finlaysonianum*, and *Cymbidium bicolor* subsp. *pubescens* (Yam 2008). From 2009 to 2012, NParks plans to enlarge these reintroduction efforts by planting 5,500 plants consisting of 12 species in many parts of the island.

The most effective way to conserve species is to propagate them through seeds by sexual reproduction. Cross-pollination is carried out between two different clones of the same species, through which genetic recombination would result in more variable and vigorous offspring. However, if only one plant is available, self-pollination has to be carried out, but this may not result in seed formation because not all orchids are sexually self-compatible. Because orchid seeds are the smallest among all flowering plants and do not have food-storage cells, they require the presence of a fungus to supply them with nutrients. Most tropical seeds, especially the epiphytes, can be germinated on a sterile nutrient medium (such as Knudson C) with the addition of sucrose (Arditti et al. 1982; Knudson 1946; Yam and Weatherhead 1988). Six to 12 months after germination, the seedlings are ready to be transplanted out of flasks.

For epiphytes such as *Bulbophyllum* and *Dendrobium*, a handful of seedlings are planted onto community pots, using small charcoal and brick chips as media. When the seedlings become established, five to 10 seedlings can be planted on a fern bark. In about one to two years' time, depending on the species, the seedlings are mature enough to be planted on trees. For terrestrial orchids, seedlings are grown in soil compositions of top soil (30%), sand (30%), compost (20%), and charcoal chips (10%). They can be planted in soil one to two years after deflasking.

NParks has propagated many species and have successfully reintroduced the following back to the natural areas in Singapore: *Grammatophyllum speciosum*, the tiger orchid, *Bulbophyllum vaginatum*, *Bulbo-*

phyllum membranaceum, *Cymbidium finlaysonianum*, *Cymbidium bicolor* subsp. *pubescens*, and *Thrixspermum amplexicaule* (Yam 2008).

Grammatophyllum speciosum

In the late 1996, a Tiger Orchid in the Gardens flowered and was self-pollinated. The huge fruit was harvested seven months later and the seeds germinated one month after being sown on Knudson C medium (Knudson 1946). After growing for 12 months in the laboratory, seedlings were planted in the nursery.

Since *G. speciosum* occurred naturally in Pulau Ubin, the first batch of seedlings was reintroduced there in July 1999 when they were 26 months old and about 15 to 20 centimetres tall with five to six leaves. They were affixed on *Durio kutejensis* (durian), *Nephelium lappaceum* (rambutan), *Mangifera indica* (mango), *Pterocarpus indicus* (Angsana), *Fagraea fragrans* (Tembusu), and *Samanea saman* (rain trees). Seedlings were also planted on trees in the Gardens, around the Visitor Centre at the Bukit Timah Nature Reserve, and in the Orchard Boulevard area in the heart of the city.

With experience from the initial trials, it was decided that seedlings would be introduced to the Bukit Batok Nature Park in the beginning of 2001. This time, the seedlings were more mature, about 30 to 40 centimetres tall with 16 to 20 leaves. They had at least three shoots, a well-established root system, and fleshy pseudobulbs. In February 2001, these larger seedlings were planted on trees along Orchard Boulevard and on the yellow rain trees surrounding the Bandstand in the Gardens. In April 2001, this species was introduced to a site adjacent to a mangrove area in Pulau Ubin, and in early May again to the Bukit Timah Nature Reserve. About 40 seedlings were also planted on rain trees along Holland Road. In December 2002, some 40 seedlings were planted on trees at the Upper Pierce Reservoir. In 2004, approximately 20 plants were planted at various urban parks such as Sembawang Park, Kent Ridge Park, and Tiong Bahru Park.

The seedlings planted have been growing for five to 10 years at the



Bulbophyllum blumei planted growing nicely at MacRitchie Reservoir.



Bulbophyllum sessile growing naturally at the Ngee Soon Swamp Forest.



First flowering of reintroduced Tiger Orchid at the Sungei Buloh Wetland Reserve in 2006.



Liparis ferruginea.



Bulbophyllum blumei planted on a rain tree along Napier Road.



Liparis ferruginea was reintroduced to Tampines Eco Green on 20 October 2011.



Cymbidium finlaysonianum, *Cymbidium bicolor* subsp. *pubescens*, and *Grammatophyllum speciosum* planted on a rain tree at Napier Road.



Cymbidium bicolor subsp. *pubescens* flowered on a rain tree at Diary Farm in March 2010.



LEFT TO RIGHT Reintroduced *Cymbidium bicolor* subsp. *pubescens* fruited at Dairy Farm in March 2010; Reintroduced *Thrixspermum amplexicaule* establishing nicely in Pulau Ubin; *Thrixspermum amplexicaule* growing well at Singapore Quarry six months after reintroduction; Reintroduced *Bulbophyllum vaginatum* flowered at Tiong Bahru Park.

various locations. More than 80 percent are doing well. New shoots have developed and the roots are firmly established on tree trunks. Unfortunately, most seedlings planted in the Bukit Timah Nature Reserve were damaged or removed by animals, probably squirrels and monkeys.

Bulbophyllum vaginatum and Bulbophyllum membranaceum

Mature seed capsules of *Bulbophyllum vaginatum* and *Bulbophyllum membranaceum* were collected from plants growing at their natural habitats. The seeds were then sown on Knudson C medium. Seedlings were grown on the media to heights of two to three centimetres tall before being transferred to the nursery. Some 10 seedlings were planted per fern bark (trunk of dead tree fern) measuring seven centimetres long by five centimetres wide. They were grown at the nursery for six months until new shoots began to emerge before reintroduction. Host trees were selected based on the same criteria used for reintroducing the Tiger Orchid. When a suitable tree is selected, fern barks with established seedlings were secured on the tree trunk by horticultural wires or nails. The seedlings are best planted in partially shady areas, with at least 50 percent shade, to avoid being scorched. After more than four years of reintroduction, more than 80 percent of the reintroduced plants survived, and most of the seedlings produced new shoots and their roots have grown onto the bark of the host trees. Some reintroduced plants have flowered.

Cymbidium bicolor subsp. pubescens

Cymbidium bicolor subsp. *pubescens* is critically endangered, with only one plant left in Singapore, found in Sungei Buloh Wetland Reserve. Seeds were collected from this plant several years ago. The seeds were sown on Knudson C medium. Seedlings were grown on the medium to four centimetres tall before being transferred to the nursery. Two seedlings were planted per fern bark, measuring seven centimetres long by five centimetres wide. They were grown at the nursery for about one year when new shoots began to develop and were ready for reintroduction. Host trees were selected based on the same criteria used for reintroducing the Tiger Orchid. When a suitable tree is selected, fern barks with established seedlings were secured on the tree trunk by horticultural wires or nails. Once more, the seedlings are

best planted in partially shady area, with at least 50 percent shade, to avoid being scorched. Some of the seedlings flowered in May 2009 and March 2010. Some seed capsules were collected from plants planted on a rain tree outside the Dairy Farm Visitor Centre in March 2010.

Liparis ferruginea

Liparis ferruginea is a critically endangered terrestrial orchid in Singapore. The plants were typically collected from swampy grounds such as near a "reservoir's siltation pond". It is a pioneer herb that can take the full exposure of the tropical sun. Two forms of this species have been found, one with "dark flower form" and the other "yellow flower form". Seedlings have been raised and reintroduced to Tampines Eco Green and Pulau Ubin in October 2011. The species is also distributed in China, Cambodia, Laos, Thailand, Malaysia, Borneo, Java and Sumatra.

Thrixspermum amplexicaule

Most *Thrixspermum* species are epiphytes. Several species have been recorded in Singapore. They are *Thrixspermum calceolus*, *T. amplexicaule* (or *T. lilacinum*), *T. notabile*, *T. ridleyanum*, and *T. trichoglossis*. *Thrixspermum amplexicaule* is an interesting species because it grows in a semi-aquatic environment. The lower half of the plant grows submerged in water. It grows near fresh water bodies such as fresh water swamps or back mangrove areas. The flowers are attractive, pale lilac in colour, and about three centimetres across. There are only a few populations left on the island. Flowers of this critically endangered species only last for one day. Seedlings have been raised from seeds collected from some Singapore native plants. Seedlings are grown in soil compositions of top soil (30%), sand (30%), compost (20%), and charcoal chips (10%). Three seedlings are tied to a bamboo pole about 30 centimetres long with horticultural wires. Once the seedlings reach about 25 centimetres in length, they can be planted in the field. The best time to do this is during the rainy season, from mid-October to December. With plenty of water supply, new roots can emerge and the seedlings can establish quickly in their new home. Locations for reintroduction must have a body of fresh water, such as the edge of pond. Other aquatic plants are needed to provide shelter and support for the young plants, for example, mangrove ferns (*Acrostichum aureum* and

Acrostichum speciosum) and *Papyrus* (*Cyperus papyrus*). To carry out the planting, bamboo poles with three seedlings attached are removed from the pots with no soil attached. The bamboo is inserted into the soil near the base of support plants. The base of seedlings should be submerged in water after planting. More than 80 percent of the reintroduced plants are able to survive by using this method of planting.

Learning points

Microclimate of the area such as relative humidity

Seedlings planted in areas with high relative humidity tend to survive better than those in dry areas. For example, in Pulau Ubin, seedlings established in a damp area inside a secondary forest are healthier and more vigorous than those growing near the sea where the breeze tends to dry the bark faster. Orchids planted at a forested area such as MacRitchie Reservoir grow well without any watering even during drought periods.

Host tree species and the presence of other epiphytes

Trees that support more epiphytes tend to be better hosts than those with fewer epiphytes. If the conditions are suitable for other epiphytes, then they are also more appropriate for epiphytic orchids too. Young trees do not have epiphytes growing on them because of their fine bark textures. When trees reach 15 to 20 years, the tree surfaces become rougher, and epiphytes such as mosses and liverworts begin to appear. When dead leaves from surrounding trees fall within the cracks and crevices of an old tree trunk, they decay, and the resulting humus not only holds water but also provides nutrients for the epiphytes. These pockets of organic matter also create suitable habitats for the germination and subsequent development of orchid seeds dispersed by the wind. The best location for the epiphytes to thrive in are the forks of the main branches. When water flows from the top of the tree to the ground, it tends to pass through the fork area before coming down to the ground. Therefore, the fork areas tend to accumulate more moisture and are more suitable for epiphytes to thrive. Some of the roadside trees that are suitable for epiphytes are: the Rain Tree (*Samanea saman*), Acacia (*Acacia auriculiformis*), the Mahogany (*Swietenia macrophylla*), the Madras Thorn (*Pithecellobium dulce*), the Yellow Flame (*Peltophorum pterocarpum*), and the Angsana (*Pterocarpus indicus*). Of these, the Rain Tree exhibits the most luxuriant growth of epiphytic plants. The most common epiphyte is Bird's Nest Fern (*Asplenium nidus*) and the most common orchid is *Dendrobium crumenatum*, also known as the Pigeon Orchid.

Size of plants

The size of seedlings is also an important factor in determining survival. For example, *Grammatophyllum speciosum* seedlings with 16 to 20 leaves (30 to 40 centimetres tall) tend to survive better than those with only five leaves (15 to 20 centimetres tall). For sympodial species such as *Bulbophyllum vaginatum*, it is better to plant larger plants with at least 10 pseudobulbs.

Time of planting


The best time for planting is during the rainy season (from October to December). Seedlings planted during this period establish themselves quickly by producing new shoots and roots. Once the roots attach themselves to the tree bark, they can absorb water and nutrients directly from the environment.

Maintenance

Our aim is to have as little maintenance as possible. Orchids planted under the right microclimate should be able to thrive by themselves like other epiphytes. Therefore very little maintenance is needed. In the case of a severe drought, plants can be drenched twice a week. If plants are reintroduced during the dry season or planted at more exposed locations, it is necessary to water them at least three times a week. Once the roots of the newly planted orchids attach themselves to the tree trunk, watering can be reduced.

When dead leaves from trees fall within the cracks and crevices of old tree trunks and decay, the resulting humus holds water and also provides nutrients for the epiphytes. The reintroduced orchids should be able to thrive like other epiphytes without the application of fertilisers. In order to help the seedlings to establish faster, a light, balanced foliar fertiliser can be applied one month after planting, for a period of six months.

Conclusion

It is hoped that the reintroduced species would be able to survive and self propagate and act as catalysts in the restoration of at least part of the original ecosystem. For example, pollinators may be attracted to come back to pollinate the flowers. Orchid seeds that are formed naturally after flowers are pollinated may be blown to the proper environment where appropriate mycorrhizal fungi are present. Perhaps one day, natural populations of native species will have sprouted up all over the island! 

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