

ADAPTATION OF FERNS OF SINGAPORE AND MALAYSIA

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INTRODUCTION

Even before working in Horticulture I was always intrigued by ferns, with a strong focus on our British natives. I attended a fern botanising course in the Cairngorms in Scotland a few years ago and there learnt the immeasurable educational value of seeing plants in their natural habitat. As my Horticultural career progressed, my focus turned more towards Tropical plants and I became employed at the glasshouses in Kew Gardens. At this point, the world of Tropical ferns was opened up to me and a whole new phase of my long-standing interest was born. It therefore seemed natural to apply for a travel bursary to see Tropical ferns in-situ, and take the opportunity to delve more deeply into the entire world of Pteridophytes.

Pteridophytes of all shapes and sizes form a significant part of the flora in ecosystems all over the world, and can be found from sea level to high mountains. There are considered to be roughly 13,000 species of fern today, and despite lacking flowers, the diversity of their appearance is astonishing. Though ferns are predominately shade loving plants, they can be found in a variety of environments all over the world. They are often pioneer species and can be problematically prolific colonisers, meaning they can sometimes be dismissed as less intriguing to investigate than more rare or sensitive plants. However, the sheer variety they offer is dazzling, and within the order you have plants that are terrestrial, epiphytic, aquatic, lithophytic and alpine.

For a fern enthusiast like myself, the land mass of Malaysia with its varied ecology and extraordinary diversity is an ideal place in which to explore the full breadth of their varieties and adaptations. Along with the heavy monsoon rainfalls which results in an average of 250cm in a year, the average higher temperature in comparison to more temperate areas also aids the flourishing of ferns. In the Malaysian Peninsular 640 species of ferns are represented (5% of the world's total) and in Sarawak Borneo there are 757 recorded species, making these regions some of the most fern rich in the world.

The two major territories of Malaysia are Peninsular Malaysia and the Malaysian areas of Borneo; Sabah and Sarawak, with the separate country of Singapore located just on the tip of the Peninsular Island. Between these areas, there are significant differences in the types and distributions of flora, and all have endemics unique to their land. It is regularly acknowledged that Borneo is one of the most important centres of plant diversity in the world, estimated to contain about 12,000- 15,000 species of vascular plants; about 5-6% of the world total.

Singapore used to be a major contributor to the biodiversity of the land mass of Malaysia, but fast economic development and intense urbanisation have led to a drastic decline in endemic species. However in 1967, the 'Garden City' concept was introduced to Singapore; a program for the intense greening up of the city, and in 2009 this was furthered to include the National Biodiversity Strategy and Action Plan for Biodiversity Conservation. Since then many native species have been reintroduced and with some of the most famous botanic and ornamental gardens in the world boasting impressive collections, it is still an informative place to visit on any plant investigation trip in the region.

The variety of ecosystems within Malaysia, with the differing climactic conditions, topography, exposure and light quality offered by each, ensure the development of a unique range of flora. The country boasts some of the longest stretches of mangroves in the world, one of the world's oldest and most untouched areas of tropical rainforest and the highest mountain in South-East Asia. In Sabah and Sarawak there are wide areas of lowland rainforest, mountain rainforest and mangroves, as well as five of the highest peaks in Malaysia, each of which presents a unique physical geography and diverse conditions for producing a range of flora. Combined with the diverse ecosystems, Malaysia also has the highest surface area of ultramafic rock in the world, further contributing to an overall increase in species diversity across the country.

In each of this multitude of microhabitats, an extraordinary range of ferns can be found. Viewing Pteridophytes in-situ in a variety of ecosystems is the best way to fully appreciate the great diversity of their leaf form and adaptation, as they adjust and form to exploit every possible niche, and Malaysia and its surrounding islands offers a perfect range to explore.

AIMS

- To learn more about the ferns of Malaysia and Singapore and how to identify them.
- To see a variety of native and endemic Malaysian and Singaporean ferns in the wild
- To Visit a variety of ecosystems across Malaysia and learn how the native ferns of each are adapted to cope with the varying conditions
- To explore how different ecosystems affect the types of species and distribution of ferns
- To see curated collections of tropical ferns in Singaporean Botanic Gardens
- Learn more about endangered ferns and of any conservation projects being implemented
- To expand my overall knowledge of Tropical Flora and different ecosystems/biomes
- To create industry contacts and connections across Malaysia and Singapore

OBJECTIVES

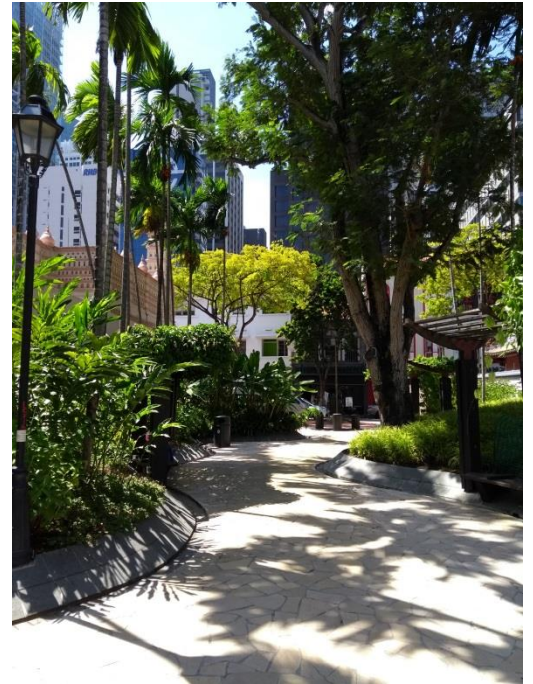
- To research a variety of ferns by speaking to and learning from professionals at different Botanic Gardens.
- To meet, discuss and learn more about Malaysian flora, with Research Officers from the Forest Research Institute Malaysia.
- To learn more about different methods of care and maintenance of ferns, by speaking to horticultural professionals in charge of public displays in gardens.
- To observe the difference between ferns in the wild and cultivated ferns, by visiting National Parks and Botanic Gardens, taking photos and notes
- To use a key or identification books whilst going on treks, to better learn how to identify different tropical ferns.
- To explore and observe the reasons for the differences in fern floras across different regions, by visiting a variety of areas and taking notes and photos on the different species and distribution
- To compile all my findings into a report for fellow students, colleagues and other interested parties

SINGAPORE

My trip was to start in Singapore, where I planned to see the ferns of Malaysia and Singapore in cultivation. I hoped this would aid me in identifying them when I eventually encountered them in the wild.

I arrived in Singapore late in the afternoon, and from the moment I drove out the airport in a taxi, I was amazed by the rich variety of plants lining the streets. Singapore is known as the 'Garden City' with an ongoing program to improve its sustainability and environmental impact and, and I had been curious to see for myself how this vision was implemented in reality. Although my main focus was to be on the ferns, I was still keen to see the greening up of such a modern city and explore the variety of tropical plants.

The immediate effect certainly was impressive, and gave me a sense of experiencing something genuinely innovative and new. I drove past arching high rises, agleam with glass and chrome, a typical modern city- but all interspersed with a generous mixture of greenery; various Leguminous trees such as *Albizia* and *Caesilpinioides* lined the pavements, their branches heavy with epiphytes. There were green spaces on every corner, rows of



Greenery in Singapore



Streets lined with beds of Tropical plants

Brownea grandiceps providing shade on a hot afternoon. A small public park by a temple was lined with *Pinanga coronaria* and a creeping *Thunbergia* was draped over a trellis archway. Ferns were abundant everywhere, with huge *Asplenium nidus* spilling out of the beds, along with arching fronds of *Nephrolepis falcata*.

Every tree in the city is mapped and monitored, and there are currently over 3, 000, 000 trees on Nparks (the governmental body in charge of the greening of the city) records. There has recently been a new initiative introduced to focus on planting not just ornamental tropical trees, but endemic species of Singapore and Malaysia.

Green building has been mandatory since 2008 and there are plenty of 'green incentives' to push new developers to go even further. Greenery lost on the ground through development must be replaced by greenery higher up, in roof top gardens and green walls. The difference this makes is immediately noticeable- although concrete is still prominent, there is also a sense of cool, calm nature

interwoven into the cities structure. Birds can be heard chirping, and plenty of shade can be found under trees. There are thick beds lining the pavement, filled with various *Hedychiums*, *Musas*, *Hymenocallis lirioides* and even bushes of the threatened *Kopsia singaporensis*. I felt genuinely uplifted at this glimpse of a solution to one of the many problems our increasing reliance on city life is causing, and it was cheering to know that in such an economically vibrant and thriving city, the vital importance of nature had not been forgotten.

GARDENS BY THE BAY

The next day, again swelteringly hot with ice blue skies, I set off to Marina Drive on one the cities impeccably timed buses to see Singapore's most modern and famous green space; Gardens by the Bay.



Super tree Grove

I soon discovered it to be not only a supremely futuristic vision of a green future but also a superlative example of thoughtful and ornamental planting done in a sustainable way.

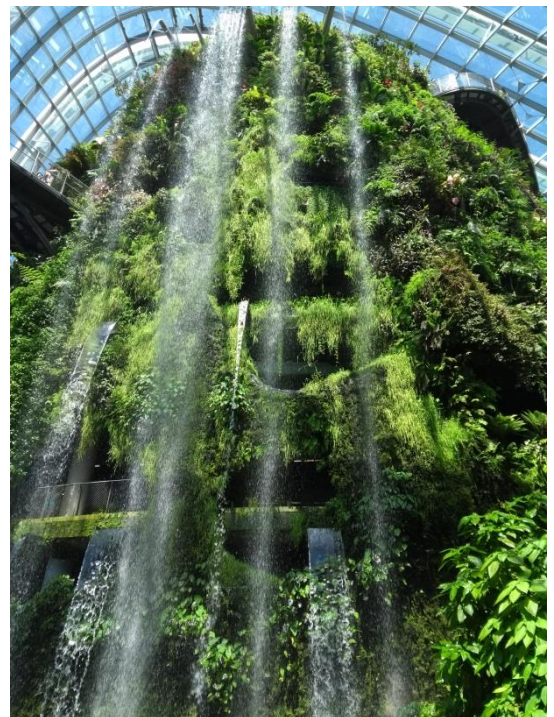
As I entered, the first thing I encountered was the famous Supertree grove. These 12 towering structures are planted all the way up their 22metre trunks and stand tall in a clean, precisely planted garden space, rich with tropical plants. On the ground is purple striped *Tradescantia zebrina* and the branches of the trees are heavy with epiphytic ferns such as *Platyserium bifurcatum* and the vigorous *Asplenium nidus*. Creeping up the towers themselves are *Vander orchids* and *Neroregelia* and *Rhaphidophora*.

The mushrooming shapes on the top

of the towers are fitted with solar panels, which harvest energy by day to power their light shows at night. It is one of the many ways in which the gardens aim to be a sustainable attraction.

I next entered the Cloud Dome; a futuristic dome of glass and steel, representing the cloud forests of the world; an ecosystem which represents 25% of the world's tropical forests. Cloud forests are a minimum of 750m above sea level and the misty atmosphere means they are rich with plant life, particularly orchids, ferns and mosses.

On entering the Cloud Dome, you are greeted by an artificial waterfall water cascading down from 35 metres above, the entire structure thickly planted on all sides. The planting



Artificial Waterfall in the Cloud Grove

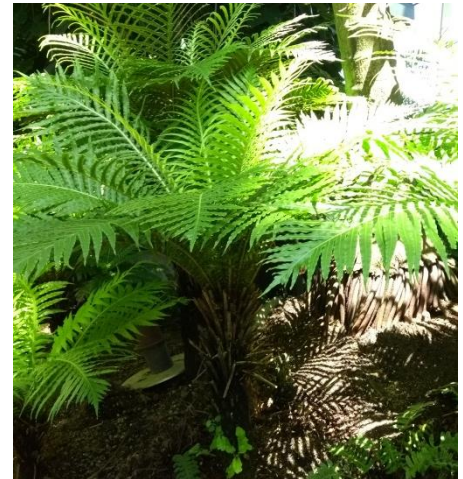
artfully blends different leaf shapes and colours to create a textured patchwork of foliage. There is *Anthurium veitchii* and *Xanthosoma sagittifolium* displaying their huge, architectural leaves, and soft, lacy falls of *Adiantum radiannum* and *Nephrolepis biserrata*.

In the beds were *Dicksonia antarctica*, their trunks thick with moss and epiphytic orchids such as *Cymbidium bicolour* and



Adiantum, Begonias and Caladiums

Bulbophyllum pileatum. The beds were deeply planted with an astonishing



Fern bed planted with Blechnum orientale

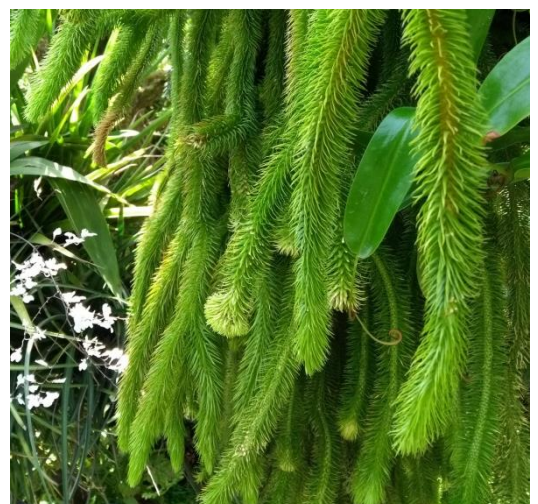
array of ferns; various species of *Adiantum*, *Cyrtomium*, *Nephrolepis*, *Pteris*, *Osmunda* and *Blechnum*, as well as *Medinilla*, *Philodendrons* and *Begonias*. Everywhere, the planting was immaculate, each specimen healthy and carefully maintained.

Higher up in the cloud forest display, unusual Lycophytes could be seen. Lycophytes were historically part of the group commonly known as 'Fern-Allies', a group of spore producing plants which included the Horse tails and Whisk Ferns. Lycophytes are now in their own group but are still considered closely related to ferns and in common parlance they are often still referred to

as Pteridophytes. A particularly beautiful *Lycopodium squarrosum* was on display, hanging in thick, furry tendrils from the branches of a tree. In a lower level of the dome, where the air was damper and the light lower, the Lycophyte *Huperzia* was hanging long, elegant tendrils over the rocks.

The opulence and extravagance of the display was astounding, which made its sustainable message and ethos even more impressive. Everywhere, the gardens conservation focus was emphasised, and in a display room, a video explained all the sustainability methods employed. All rainwater is stored and re-used, as is any run off. Mangrove ponds and reeds provide the first step of water filtration, and all felled trees and fallen leaves are collected and burnt in a biomass generator, to create the energy required to cool the domes.

The variety of plants to see, particularly ferns, was dazzling, and it proved to be an ideal first stop for the trip. Seeing the plants I would shortly encounter in the wild, perfectly



Lycopodium squarrosum

cultivated, was a huge aid in honing my identification skills. Furthermore, the gardens clear and urgent message regarding conservation and climate change was relevant and necessary, and brought the fragility of the ecosystems I was to visit into sharp relief.

SINGAPORE BOTANIC GARDEN



Entrance to the Botanic Gardens

The next day the temperature had soared even higher as I set off to Singapore Botanic Gardens to meet Noura Abdul- the deputy manager of the establishment. The Botanic Garden is a fully funded governmental body, so it is free for public to visit.

The immediate impression of the gardens was lush and well-kept, full of towering trees providing shade, sweeping lawns and a few old colonial buildings, indicating its history of 160 years. One of the first trees I encountered was the stunning *Lecythis pisonis*-a vast Monkey Pot tree, producing a sweet scent and dropping its distinctive, pot- shaped seed pods on the path.

I met Noura at the Library and Herbarium, and we drove through the garden on an electric buggy, to ensure we could cover most of the 82 hectares within the day. We stopped first at the 6hectares of primary forest the garden still has, which is left by staff to be as unmanaged as possible. There are ancient Dipterocarps and many native species in the forest, which is much denser and darker than the rest of the garden. After tropical storms trees will occasionally fall and only then staff will go in to plant a few native species which they grow in a nearby nursery. Otherwise, low intensity management is the key, to ensure the forest maintains the delicate balance it manages between all the species of its ecosystem.



Lecythis pisonis laden with *Epiphytes*

Most of Singapore's native plants have become extinct; out of its original 2000 only 17 are left. Therefore no part of the garden has only pure endemic species, but borrows from neighbouring Malaysia. Due to Singapore's issues with species diversity it was decided that maintaining endemic purity merely for the sake of it was not the best method of conservation.

The garden itself is a haven for wildlife, and everywhere I looked there were monitor lizards skulking in the shadows, otters trotting

across the paths, bats hanging in the trees and Drongos perched high on branches. The garden also aims for sustainability as much as possible, and all its water needs are met by its 4 lakes. Chemical pesticides are rarely used, only pheromone traps, and the fertiliser is bone meal feed liberally applied throughout the growing season.

Like so much of Singapore, the garden is immaculate and everywhere there were staff members clearing paths and beds. Noura explained that in Singapore an organisation can be fined for having any pools of stagnant water on their property as they attract mosquitos. The staff must therefore constantly scour the garden, levelling out any dips or uneven ground where water can settle.

The paths are lined with rows of *Cyrtostachys renda*- the 'Red Sealing Wax Palm' or 'Lipstick Palm', the plant which is the symbol of the garden, embroidered on staff shirts and engraved on the front gates.



Pteris cretica 'Albolineata'



Bolbitis appendiculata

The Fernery was our final stop, and was located in a cool, damp enclave. There were large beds, thick with moss, and each over spilling with a variety of ferns. Noura laughingly told me

that management of the fernery was very low maintenance, as in the tropical climate they grow like weeds. She was interested to hear about the careful temperature control, the constant misting and the daily watering required to maintain the tropical

collections at Kew.

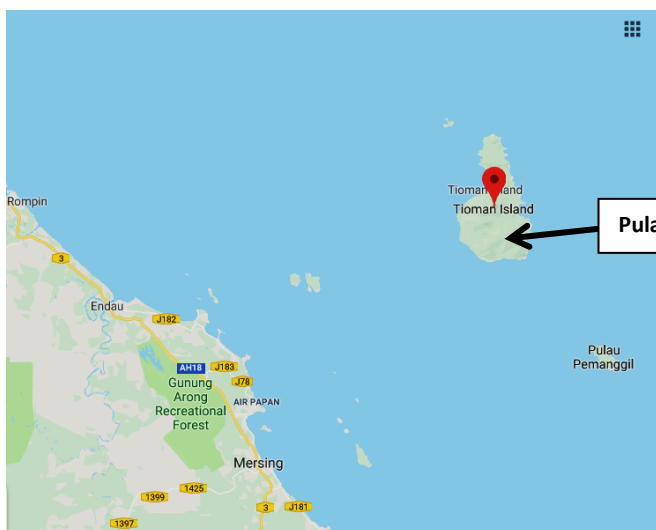
The collection was pleasingly diverse with huge *Angiopteris evecta* providing shelter, and plenty of *Pteris cretica* 'Albolineata' a beautiful cultivar with a clean white, central stripe. Many of the genera and species were new to me, including *Bolbitis appendiculata*, a compact terrestrial with rounded, lobed fronds and *Asplenium thunbergii*, an *Asplenium* very different from the usual, with feathery, delicate fronds, and a low growth.

MALAYSIA

PULAU TIOMAN

After Singapore, my first Malaysian stop was to be Pulau Tioman and I left the mainland early in the morning to catch the boat to the island. Having seen so many stunning ferns of the region in cultivation, I was now keen to finally see some of them in-situ.

Pulau Tioman is just 21 kilometres long and 12 kilometres wide, and is an IUCN listed site of plant diversity and endemism. With a total recorded number of 154 species, Pulau Tioman represents



23.5% of the total Pteridophyte species in Peninsular Malaysia. I had decided it was an excellent place to start viewing native ferns in the wild, due to being manageably compact but richly dense with interesting variety. Pulau Tioman's main ecosystems are mangrove forest, coastal vegetation, lowland dipterocarp forest and hill dipterocarp forest, all at a much lower elevation than places I planned to view on the

latter part of the trip.

As the boat came in to land, I saw a pristine coastline of white sand with a looming mountain covered in vibrant green rainforest as a backdrop. Along the beach were rows of *Casuarina equisetifolia*, planted as a windbreak and to prevent coastal erosion. In traditional mythology, it is said that Tioman Mountain is the embodiment of a Dragon Princess, who stopped for a rest on her way to meet her prince in Singapore. Charmed by the beauty of the island, she decided to stay forever and become the guardian of the place.

On the first day, I had organised a hike with a guide named Musa from the main town of Tekek,



Selaginella wildenowii

heading straight across the island and through the forest to the town of Juara on the opposite side. It was a 9km hike and the highest point was 700 metres above sea level. The forest we passed through was mostly lowland Dipterocarp forest, all of it protected. Lowland Dipterocarp forest is one of the most biodiverse ecosystems on the planet, and above 500m but under 1000m a particularly wide range of flora can be expected. The Dipterocarp forests of Malaysia have particularly high species diversity, and the soaring canopy can reach up to 50metres overhead. The dense canopy



means that a large number of epiphytes can be found, and terrestrial ferns thrive in the shrub layer, with their superior ability to exist in low light levels.

As we made our way off the main path and begun walking towards the forest, the first plants we were greeted by was thick banks of *Dicranopteris linearis*, a fern that quickly colonises disturbed habitats and steep slopes. This was interspersed with low, shimmering thickets of the iridescent *Selaginella wildenowii* - a blue Selaginella with an oil-slick shine that comes from the fracturing of the light hitting the angled surface of its fronds. The climbing fern *Lygodium flexuosum*, with its lacy fertile fronds scrambled over a low wall, and snaked across the earth, entwining itself with mounds of *Mimosa pudica*; the pom-pom flowered sensitive plant. *Pyrossia serpens*, a common climbing fern which has thick, almost succulent fronds, crept up the trunks of the

last of the palms lining the road, before the trees gave way to the Dipterocarps of the forest.

We entered the forest and instantly the temperature dropped and the light dimmed as the soaring trees shaded out the sun. I was immediately aware of the sheer density of the variety of life around me. The air was thick with the sound of chattering insects and the light was the watery, jade green so typically associated with tropical forests. Clearly graded storeys were evident at a glance; the emergent heads of the Dipterocarps high ahead, the thick hangings of epiphytes tangled in the canopy, the dense growth of palms such as *Caryota mitis* and *Calamus* creating a green understory, and a pleasingly diverse forest floor covering of creeping and terrestrial ferns.

There were *Anisoptera curtisii* and *Hopea nutans*, both of which are threatened Dipterocarp species. There were also a wide variety of Ficus trees spreading their tangling roots far across the forest floor.

As soon as we started walking, I realised the forest was rich with ferns, small creeping ones becoming larger and denser as we trekked upwards and the vegetation became thicker. There were shiny fronds of *Stenochlaena palustris*, growing far larger and longer than I had ever seen them in cultivation. There was a huge range of sizes and textures, from the tiny, creeping fern *Lindsaea oblanceolata*, with rounded, dark green, glossy fronds, to the long, smooth, drooping arms of the classic epiphyte *Asplenium nidus*, perched high in the branches of a tree.



Ficus trunks

As we reached the midway point of our journey and the highest point of the hike, I was excited to see some tall tree ferns- *Cyathea capitata* perched on a slope. Due to the low light, they were still fairly thin, but still had impressive, arching fronds which tickled the floor.

The elevation started to drop after this, and soon I noticed the trees thinning out and more light being let through. As we climbed down, I also became aware of the increasing heat and sticky humidity, and it wasn't long before I saw a strip of blue sea in the distance. Palms started returning to the landscape as the Dipterocarps dropped away, and soon we found ourselves walking on the dusty road heading into Juara village.



Drynaria quercifolia

This time, I noticed immediately that the canopy was denser and the entire forest was dimmer, with a thicker covering of dead leaves blanketing the ground, suggesting a slower decomposition rate. The incline was much steeper on this hike, and on several occasions we had to pull ourselves up over rocks with ropes that Musa had previously strung in place to aid hikers. As we passed one particularly enormous boulder, I saw an impressively sized *Drynaria quercifolia* growing across it. It had beautiful, fat furry rhizomes helping it cling to the bare rock surface. The distinctively *quercus* shaped sterile nest fronds were very prominent, creating a perfect basket to aid the fern in catching the falling debris from the trees above.

Further on, we came to an area which had been lightly cleared and here the vegetation suddenly became a bright, vibrant green again as plenty of pioneer species took advantage of the sudden uptake in light levels. Due to the disturbed ground, tangles of *Dicranopteris linearis* had begun to create their distinctive, geometric thickets. Within this, I was excited to see a

The next day, I met Musa again for another trek, this time to a higher point of the island. We drove for 40 minutes, winding in circles up the precarious mountain roads, passing hordes of wide eyed monkeys, watching us with interest from their tree top perches. We hoped to see an even wider mix of ferns, but Musa had also heard a rumour that there was a flowering *Rafflesia* in the forest, and we were hopeful that we would get a glimpse.



Angiopteris evecta

grouping of immense, elegantly arched *Angiopteris evecta*- the elephant fern. The increased light and sudden lack of competition meant that these ferns had been able to reach some impressive heights, and they towered over us. The base of each frond was nearly as thick as an arm, and each neatly pointed pinnule was nearly 6 inches in length. Although native to Malaysia, *Angiopteris evecta* can be invasive in other countries due to its height and vigour and ability to shade out other plants. *Angiopteris* is an unusual genus, which diverged from the more familiar fern lineages fairly early on, and surprisingly, is therefore thought to be more closely related to *Psilotales* (Whisk ferns) and *Equisetales* (Horsetails) than the *Polypodiales*.¹

As we continued the hike, I began to notice more clumps of *Angiopteris* dotted through the forest. Musa then noticed a promising looking red-bud in the distance, growing cauliflorously out of a tree trunk. We approached, and Musa pointed ahead to a wide, bizarre looking, rust-red flower; a *Rafflesia cantleyi*. Considering its brief blooming period, it was extremely fortunate to see one open and the flower was even more indescribably strange than I had imagined. It grew directly out of the vines of the host plant it was parasitizing, utterly dwarfing



Rafflesia cantleyi

it with its huge size. This particular one was roughly 50cm across, with irregular, white warts across its waxy red petals. The unopened buds were black and tightly folded into balls, dotted up along the trunk of its host. One half-opened flower was growing directly out of the ground, where it was emerging from the roots of the host tree. The smell was not as pungent as I had expected, which

Musa explained was because although the flower was large, it was not yet fully open.



Amorphophallus paeoniifolius

Continuing with the hike, I shortly noticed an *Amorphophallus paeoniifolius*. This is widely cultivated as a food crop in South Asia, where people eat the large tubers, but in Tioman it simply grows wild. The leaf had a distinctive, mottled petiole and was nearly a

meter tall. Although common in South East Asia, and even though it was not the famous *Titanum arum*, it was still interesting to see an *Amorphophallus* in situ. Even surrounded by thick forest foliage, it looked distinctive, with its Dalmatian spotted petiole and the geometric fan of its lone leaf.

Tioman had proved to be as rich with flora as I had hoped, and had been an extremely informative introduction to Malaysian and South- East Asian ferns. With Musa's help, I had begun to feel comfortable in identifying a range of the more commonly encountered, and was particularly pleased to have seen the *Angiopteris* as well as of course the *Rafflesia*.

BORNEO- SABAH

KINABALU



My first stop in Borneo was to be in Kota Kinabalu, the capital of Sabah. I was met at the airport by Andi Maryani, a botanist with the Sabah Forestry Department, who then drove me to the Departments headquarters.

Rimy Repin, a renowned expert on ultramafic flora and the Begonias of Malaysia and Geofarry Gunsalam, a fern expert and another member of Sabah Forestry Department, were both there to meet us. Both were extremely warm and welcoming, and along with a few of their other colleagues I gave them a presentation I had previously prepared. I spoke about Kew Gardens, the work that was carried out there, my intentions for my project and what I hoped to achieve in Borneo. The team were encouraging and receptive and it was highly informative to discuss their various specialisms with them. Andi



(From left) Rimy Repin, Myself, Geofarry Gunsalam and Andi Maryani

and Geofarry were both to join me on the next leg of my journey and their enthusiasm for the native Pteridophytes of Borneo was clear. After the meeting, we set off on the long drive to Kinabalu Park.



First glimpse of Mount Kinabalu

Kinabalu Park is a UNESCO World Heritage site and its central mountain, Gunung Kinabalu, is the highest point on Borneo and a world renowned hotspot for biodiversity. With up to 6,000 recorded species, it has more floristic species than all of Europe and North America combined. The rich flora is the result of a vast range of climatic conditions

from tropical rainforests near sea level to freezing alpine conditions and the precipitous topography which creates a wide range of geographic niches.



Sabah Botanic Garden Nursery

The next morning, our first stop was the Sabah Botanic Garden and Nursery. The garden only displays plants that are endemic to Sabah, with a focus on Kinabalu specifically. The Nursery, which was established in 1980, is sponsored by the BGCI and employs six members of staff. All seeds and cuttings are naturally sourced, and though it was small, it was filled with an astonishing array of unusual plants, giving me a first taste of the immeasurable diversity I would be encountering over the next few

days. Orchids were particularly well represented, and there were some enormous *Nepenthes raja*-the Kinabalu endemic *Nepenthes*.

Geofarry outlined all the various projects that the Garden and Nursery wanted to undertake, but explained that finding sufficient funding was hard to do- something so disheartening to hear considering what vital work they were attempting. One particularly ambitious project involves re-introducing a nearly extinct, native *Rhododendron* to the Mountain, but with so few staff allocated to the task, it is proving difficult.



Impressive Epiphytes in the forest canopy

The garden is 1.4 hectares in size, but due to the varied topography, provided plenty of scope for exploration. It is mainly protected and managed forest, with additional endemics planted by the staff. Things that have been introduced are marked with 3 labels; black indicates it is common, red that it is endemic and blue, that it has medicinal properties. The garden is mostly used as an educational facility by botanical students across Malaysia, making it seem even more disappointing that it lacked government funding.

As Andi is an *Asplenium* expert, she spent a long time showing me how to identify different species within the genera by the width, shape and prominence of their midribs. The tree trunks were smothered in epiphytes;

*Dawsonia longifolia*

a combination of mosses, ferns and orchids, growing together in a riot. The forest floor had gatherings of tall moss protruding above the leaf litter, such as the fragile, star-shaped *Dawsonia longifolia*. One fern which particularly stood out to me was *Oleandra neriiformis*- it grew in an extremely uncommon shape for a fern, almost shrub-like. Its stems were so thick and stiff they almost seemed like wood, although ferns do not grow persistent woody stems, and its simple, leathery leaves were unlike any fronds I had encountered before.

At 1500m elevation, it was Lower Montane Forest and the vegetation was still dense and a deep, mineral green and the trees were thickly clustered and tall. However, the tree trunks were noticeably thinner in width than they had been in the lowland forest of Tioman, and at the herb layer the plants were generally of a more compact size.

Studies show that due to the rising moisture in the air, epiphytes thrive at an increasingly upward rate which peaks and plateaus at 1300m elevation. The epiphytes were certainly flourishing here in the humid atmosphere and were growing to sizes that dwarfed the trees they were living on. Two fifths of fern species on Kinabalu are epiphytes, so I was expecting to see an interesting range. We saw an *Asplenium splendifolium*, with fronds 30cm wide, and nearly trailing down to the ground.

*Blechnum vestitum*

We left the garden and followed the path up the mountain towards another hiking trail. Due to the lack of competition from large trees, the slope of the mountain alongside the road proved to be the most exciting mixture of ferns I had seen so far. Gathered at the base of the slope were several more *Angiopteris evecta*, even taller than the ones I had encountered in Tioman, and a compact growth of *Blechnum vestitum* showing some brilliant red fronds. We then

*Dipteris conjugata*

noticed extremely large, fan-shaped, deeply lobed fronds and realised we had stumbled upon a patch of *Dipteris conjugata*. A primitive fern in a genus of only 5 species, it can sometimes be found in clearings and is both lithophytic and terrestrial. It is critically endangered and has disappeared entirely from Singapore, where it was once native. With long trailing divisions in its huge fronds, it barely looked like a pteridophyte at all.

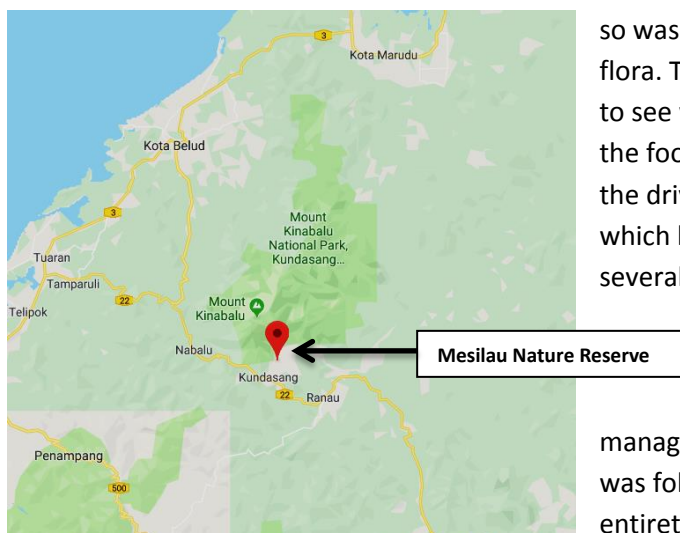


Purple and green stems of *Cyathea contaminans*

We continued to explore the paths of the hiking trail until late in the afternoon. *Cyathea contaminans* with its range of purple and green spiny stems was common, but we also saw some *Pronephrium nitidum*, with its deeply ridged, simple leaves and *Cyathea capitata*- identifiable due to its unusually wide pinna. Before returning, we headed briefly to the Sabah Parks Herbarium.

MESILAU NATURE RESERVE- KUNDANSANG

Malaysia has one of the highest surface areas of ultramafic rock in the world, a substrate that is rich with magnesium and iron but low in silica and renowned for its unique effects on the biodiversity of an area. It is due to the low silica percentage that ultramafic substrate is so rare, as it is more susceptible to disintegration. Ultramafic rock occupies < 1% of the land surface of the earth, but Sabah alone has 3500km², along with extended areas of limestone hills. These outcrops are renowned as centres of high plant diversity supporting high levels of plant endemism. Over 1500 plant species have been documented on ultramafic outcrops around Mount Kinabalu, of which a large percentage is endemic to either Mount Kinabalu or Borneo more widely.



Andi had worked extensively with Rimy Repin and so was an excellent guide to have to this unusual flora. The ultramafic outcrop that we were going to see was the Mesilau nature reserve, an area in the foothills of Kinabalu at 1400m elevation. On the drive up, Geofarry explained that the area which had once contained a large resort and several hostels, had recently suffered a tragedy.

After the earthquake in 2015, the infrastructure of the area had all been severely damaged but had just about managed to carry on. However, this earthquake was followed by a landslide in 2017 across the entirety of Kundasang, and this time the damage

was so severe that the area had had to be entirely deserted. All the roads had been destroyed, so all enterprise in the region had been abandoned. Geofarry rather bleakly noted that this did mean that the area was now even more of a botanical hotspot, as the lack of human activity meant that the plants had been left to thrive.

When we arrived, the sense of desertion in the place was immediately apparent. We drove past bungalows with the doors swinging open, revealing the emptiness within, and the reception buildings leading to the reserve looked eerie in their abandonment. It was a cool, grey day and Geofarry told us to beware of wondering too far off the path, due to the leeches.

It was fascinating to realise that all the plants growing around us had in some way adapted to the complexity of the substrate beneath our feet. Due to often being fairly hardy, some common ferns can adapt to an ultramafic environment in a way that other plants may not be able to, and there are also a few which are nickel hyperaccumulators (meaning they can withstand unusually high levels of nickel), such as *Pityrogramma calomelanos*. Ultramafic substrate is generally deficient in the macronutrients phosphorous and potassium, and also high in ferric oxide, making any phosphorous that is present even less available to plants. Plants that grow in this substrate thus tend to have a thicker, harder leaf texture and a reduced leaf size.



Pityrogramma calomelanos

It was interesting to see that the usual ferns were evident, such as *Dipteris conjugata* and *Dicranopteris linearis*, and due to the disturbance caused by the landslide, there were also huge areas entirely swamped by *Pteridium esculentum*. This proved the eternal hardiness of these pioneer fern species, seemingly unbothered by the toxic levels of nickel.

We found a fertile patch of *Belvisia spicata*, as well as a patch of the very common ornamental *Nephrolepis falcata*. This was intriguing, as it had presumably self-sown from a cultivated plant somewhere nearby, yet it was thriving in the unusual substrate with no difficulties. *Odontosoria chinensis* was found growing in lacy mounds, with its long, finely divided fronds, and on some



Matonia pectinata

exposed areas of rock, we found *Schizaea fistulosa*, an extremely small fern, commonly found on ultramafic soils. It was noticeable that all the ferns either had small or dispersed, deeply divided fronds, illustrating the fact that plants on ultramafic substrates do not commonly grow very large.

It was at this point that for the first time on my trip so far, tropical rain began to thunder down. We ran for shelter but were shortly drenched by the downpour. The forest foliage all gleamed brightly in the rain, but the abandoned huts of the reserve seemed



Mass of Lycopodiums

identified it as a potential *Huperzia carinata*.

to look even more desolately empty than before and as the ground quickly became swamp like, we decided to drive away.

On the drive back, Andi noticed a particularly promising looking slope through the window, so despite the rain we all jumped out to have a look. She had spotted the long elusive *Matonia pectinata*, which I had been keen to see due to its striking shape like a firework explosion, and the elegantly curled tips of each of its fronds. Andi explained that *Matonia* was extremely hard to transplant and so was proving difficult to conserve, which was problematic as it was becoming increasingly rare. We rounded a corner, still hunting for interesting sightings, and found a stunning slope, entirely covered in Lycopodiums. With their delicate, drooping fronds, each one curving out in an elegant arch, they looked like chandeliers, ornamental and graceful and seen growing in a way that would be impossible in cultivation. Andi

THE CROCKER RANGE- KENINGAU FERN GARDEN



Entrance to the Crocker Range

The final stop on the trip was to be the Crocker Range, where we would stay for several nights. Situated south of Mount Kinabalu, the Crocker Range forms chain mountains with no distinct peaks dissected by deep river valleys. With a temperature range between 20- 32c, the area has around 3,000 mm/year precipitation on average and is home to a wide array of endangered species.

First thing in the morning, Geofarry took us to see the Keningau Fern Garden, which he had been instrumental in helping to establish. The garden had been set up with government funding in 1996 as a fern conservation centre,

and at the last record had 326 different species of ferns from all over Sabah. The place originally had

several staff members helping to maintain it, but the team had been reduced to just three temporary workers, when the funding was cut to a mere 30, 000RM (£584) a year. It was extremely saddening to hear about yet another cut for such a vital project, and I could feel Andi and Geofarry's demoralisation as we visited site after underfunded site.

However, despite the lack of funding the area was still impressive and rich with unusual vegetation. The space was spread over several acres on an upward slope and was



Drynaria sparsisora

extremely densely planted, with huge *Cyatheas* shading out the light, leaving the place dark and damp.

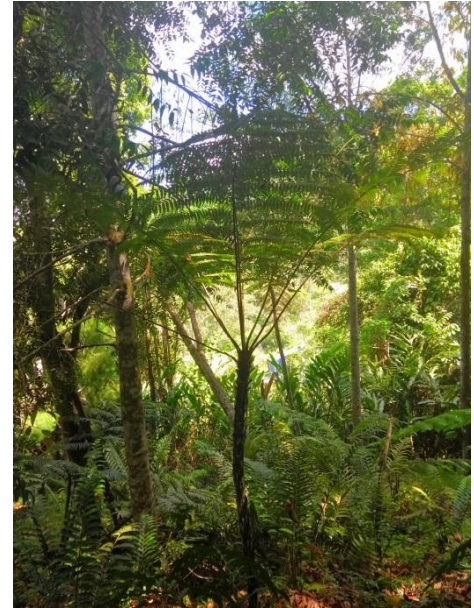
Geofarry and Andi took me on a tour of the garden, showing me the vast variety of ferns, which had both

been planted there and which had naturally spread into the space. It was an excellent opportunity to see in one place all the ferns which I may not have the opportunity to find by myself.

There was the *Cyathea* that was endemic to Kinabalu, *Cyathea havilandii* and plenty of *Cyathea ferox*, the thin, delicate tree fern. The branches of all the surrounding trees were cloaked in *Stenochlaena palustris* and *Selliguea heterocarpa* and they had set up a small pond which was covered with a mat of *Salvinia*

natans, the aquatic fern which floats by the use of air filled pouches, and uses its third, submerged leaf as a root. Huge *Didymochlaena trunculata* grew in abundance, with shining fronds, extending out far longer than ever seen in cultivation.

We left the garden after several hours of exploration and took a hike along one of the many beautiful trails across the Crocker Range. Amongst other things, we found one extremely imposing *Drynaria sparsisora* on the trail, which was free standing on the soil and large enough to sit in the crown.



Cyathea ferox

THE CROCKER RANGE- MOUNT ALAB



The Crocker Range

The next day, we drove to another point in the Crocker Range; Mount Alab. At 2200m, this was to be the highest point we had visited so far and I was intrigued to see how different the vegetation would be. The temperature was definitely a little cooler and the air very moist. We hiked up a hill to begin the trails, and just as we began we saw a small clustering of orchids growing by the side of the path. This was *Dendrobium lambii* named after the illustrious botanist and orchid conservationist Tony Lamb.

The forest that we entered was markedly different from the previous forests we had visited. This was Cloud Forest, with constant year round moisture from the low hanging atmosphere. The trunks of the trees were extremely slim and entirely covered in lichen and moss and the floor was rich with glistening mushrooms of all colours amongst the mounds of emerald moss. Due to the increased altitude, the stature of the trees was much reduced and the rain contributed to a highly acidic, humus rich soil which was soft underfoot. Cloud Forest is the type of Tropical forest being lost at the highest annual rate; due to its delicate dependency on a predictable climate it is severely affected by climate change and large areas have been cleared for montane agriculture.



Dendrobium lambii

The main attractions for us were of course the endless varieties of filmy ferns which coated every branch and trunk. All the vegetation in the forest consisted of delicate, small-leaved plants and hunting to find species required close and careful inspection. The filmy ferns were so fragile the light shone through them, and a single droplet of water could cover the entire surface of a frond. On the

whole, they were a deep, mineral green, almost black in some cases, with rounded sori prominent on the tip of each frond. *Hymenophyllaceae* is a family with 2 genera and 650 species, and Andi and Geofarry explained that due to their tiny size they were extremely hard to identify, even with a hand lens. A common one which could be identified was *Meringium microchilum*, which has the glossy fronds and bulbous sori typical of the family. The feathery, glaucous *Pleuromanes pallidum*, with tiny fronds lying in tasselled layers across the surface of a trunk, was also prevalent.



Pleuromanes pallidum

Lindsaeaceae was another widely represented family, with tiny *Lindsaea linearis* creeping up tree trunks, *Lindsaea oblanceolata* arching out of tufts of moss and stiff, shiny fronds of *Lindsaea rigida*. Even the terrestrial ferns or common epiphytes in the forest were small, as the canopy was not sufficiently developed to support anything larger, and the constant moisture and low light levels had a limiting effect on growth.

Towards the end of the hike, as light crept back into the outskirts of the forest, the terrestrial ferns became a little larger and the filmy ferns thinned out. We found a bank that was thick with mounds of *Histiopteris incisa*. This



Histiopteris incisa

fern prefers slightly lower temperatures and very moist areas and has a beautiful, light green colour, with unusual, widely spaced, curved pinna. I was pleased to have seen one last, new species as my trip was drawn to a close.



Mushrooms, mosses and ferns of a cloud forest

CONCLUSION

The trip had been more informative and eye-opening than I had even hoped. Seeing ferns in-situ gave me a much more fundamental understanding of how they grew and functioned, and what their physiology adapted them for. I had been unprepared for the sheer richness of the flora I encountered, and the wide variety of environmental conditions of the different ecosystems I visited, and how symbiotic the relationship was between the plants and their surroundings. From soaring Hardwood trees with enormous epiphytes in their canopies in a Dipterocarp forest, to the delicately tiny filmy ferns on the slender trunks of a Cloud Forest, I experienced the various subtle intricacies that are all vital to a diverse and thriving ecosystem.

However, what the trip also highlighted to me was just how fragile these ecosystems are, and the various threats they face. I met many people who worked with tireless dedication categorising and conserving the vulnerable flora, but talking to them mainly highlighted what an uphill struggle it often was. Visiting Singapore was a lesson in what could be done in the modern world to try and bring green back to our cities, but it was also an illustration of how much has already been destroyed. Across Malaysia, the lack of funding for vital projects was a constant and depressing theme.

The people I had met were certainly astonishing, in their knowledge, expertise and generosity with their time and they all supported me in more than fulfilling my aims for the trip. I returned to the UK with a renewed sense of purpose to delve deeper into the subject of botany, inspired by both the positives and the negatives I had encountered on the trip.

COSTINGS

Food	120
Accomodation	312
Transport (buses, boats and daily car hire in Borneo)	330
Flights (getting there and internal)	591.59
Guide Costs	90
Entrance Fees to parks and Gardens	16
Other (Internet café, exchange fee and call to hostel)	22
	£1481.59

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