Following the Footsteps of Naturalist Alexander Von Humboldt Through the Ecuadorian Andes

RHS Travel Scholarship Report

Figure 1: At 4,500m elevation stands the enchanting forest of Polylepis australis on Mount Chimborazo, Ecuador.

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July 2019

Royal Botanic Gardens Kew

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Introduction

My inspiration for Ecuador came when I first read Andrea Wulf's book 'The Invention of Nature: Alexander von Humboldt's New World'. This book inspired me with its tales of discovery and fascinating botanical breakthroughs. The book describes the polymath Alexander Von Humboldt through his journey down the spine of the Andean mountain range, with his quest to study the geography of the land and endemic flora. He travelled through south America with the French botanist Aime Bonpland and they collected 5,800 species of plants, of which 3,600 were unknown to science until then. Vast regions of Ecuador were undiscovered at that time which made the botanical discoveries so important. My goals are to study the flora of the Andean mountain range as Humboldt did in the hope to learn about montane forests and the diversity of species.

Ecuador is a country in the north west of South America, bordered by Colombia, Peru and the Pacific Ocean. Ecuador also includes the Galápagos Islands in the Pacific, about 1,000 kilometres west of the mainland.

The country has three main geographic regions:

La Costa, "the coast"

La Sierra, "the highlands"

La Amazonía,"the east"

These natural barriers have formed segregated regions and pools of biodiversity within Ecuador and the Galapagos islands. The combination of thousands of years of evolution and lack of human influence has allowed the richness of biodiversity to thrive. The topography of Ecuador highlights the extreme climates that occur (see fig 2). The climate in the mountain valleys is mild all year-round, with a humid subtropical climate in the coastal areas and rainforest in the lowlands. The Pacific coastal area has a tropical climate with a severe rainy season. The climate in the Andean highlands is temperate and relatively dry, and the Amazon basin on the eastern side of the mountains shares the climate of other rainforest zones.

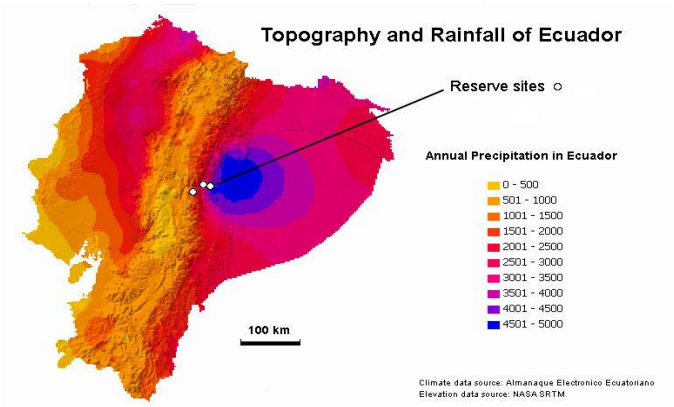

Figure 2: Topography and rainfall of Ecuador

There are about 4,500 species of endemic plants in Ecuador, 38% are orchids. There are also some 25,000 species of vascular plants in Ecuador many endemics to the country.

My interest for this travel scholarship were to visit regions of the country that Humboldt visited on his travels, such as the cloud forest, Cotopaxi province, Mount Chimborazo and the Amazon. At these different locations I will compare the habitats and native flora of the montane cloud forests, temperate *Polylepis* woodland and even the tropical Amazonian basin.

I was interested in seeing the variety of flora of these regions to see how they have adapted to their environment. Further investigations would focus on why certain taxa may form spearhead species for the protection of the habitats they reside in. many epiphytic orchids, bromeliads, anthuriums and ferns could be key species for the preservation of montane cloud forests. While the ever reducing *Polylepis* woodlands give a living history of the change in our climate. Humboldt was a pioneer for the concepts of evolution, climate change and unity of living organisms before future scientists could accumulate the knowledge into what we know today.

Aims and Objectives

- visit a range of habitats through the Andean mountains and Amazon basin.
- Study the diversity of plants in the stated habitats and how they cope with their environments.
- Understand what Quito botanic garden, Jardín Botánico Las Orquídeas and many other nature reserves throughout Ecuador are doing to protect endangered plant species
- To improve my knowledge of endemic flora of Ecuador
- To follow Humboldt's expedition through the country and use his discoveries as influence for my studies
- Visit two botanic gardens in Ecuador; Jardín Botánico Las Orquideas and Quito Botanic Garden

Benefits to Kew

To share knowledge and provide information which may be useful to:

- Improve cultivation techniques as a direct result of observing plants in situ and cultivated by other institutions
- Create links with other horticulturalists and organisations that I will be working with or visiting
- Share knowledge with staff and other students at RBG Kew
- Increase knowledge to enhance public displays

Benefits to the individual

- Gain field work experience
- Improve plant knowledge
- Networking experience
- Experience in situ and ex situ plant habitats
- Experience of working in other gardens and nature reserves
- Working with other horticulturists and scientific experts
- Act as an official ambassador for Kew
- Broaden future study and career opportunities

Itinerary

Day 1: 05//07/19 -Arrive into Quito Airport at 8:30 am (GMT -5) Find accommodation in the city, then spend the rest of the day recovering from jet lag and acclimatizing to the altitude (2,800m).

Day 2: 06/07/19 -Visit Quito Botanic Garden, spending time learning how they cultivate their collections, furthermore, observing how they recreate the countries multitude of climatic regions and diversity of flora, in a relatively small garden. Visit Pichincha volcano in the afternoon to further adjust to a higher altitude (4,000m) and see its range of flora.

Day 3: 07/07/19 -Santa Lucia Nature Reserve. Spend the day travelling to the nature reserve 80km NW of Quito, a bus from La Ofelia station in Quito will take me to Nanegal (2 hours) where I will meet Holger Beck from Santa Lucia Nature reserve in the Pichincha Province. A 30-minute truck ride will take me to the trail head, there I have a 2-hour hike up to the lodge at 1,600m above sea level.

Day 4: 08/07/19 -Receive a tour of Santa Lucia by Holger Beck to observe many different genera around the reserve. In addition to longer hikes to the reserve's larger waterfalls where a wider range of flora may be seen. And viewing their very own orchid collection in the reserve.

Day 5: 09/07/19 -Journey to Los Cedros Nature Reserve. Leave Santa Lucia reserve early around 6am to walk down the mountain for my lift back to Nanegal. There I would get a bus to Nanegalito approximately 30 minutes away, I will then be boarding a bus to Chontal, this should take approximately 1 hour. From there I am picked up by staff from Los Cedros and driven to the trail head. The hike up to the reserve will take approximately 2 hours.

Day 6: 10/07/19 – There would be no tour of the Reserve as the local guide was busy this day. However, a map would be provided of the Reserve's trails along with a book called 'Plants of Mindo: A Guide of the Cloud Forest of the Andean Choco' kindly provided by Josef DeCoux. This could give me the means to freely walk around the landscape and botanise.

Day 7: 11/07/19- Josef has kindly arranged a toured hike to view an area of primary Cloud forest thought to be disturbed by minors.

Day 8: 12/07/19- Travelling to Cotopaxi Nature Reserve would take me the entire day even though the distance was approximately 100km, the roads are very poor, and I would need get 3 separate buses.

Day 9: 13/07/19- My day at Cotopaxi would revolve entirely around the weather, any hiking up the mountain in foggy conditions is prohibited. Here I would aim to see a range of high-altitude temperate flora such as *Chiquiragua jussieui and Polylepis spp,* all which Humboldt noted seeing in his journal at Cotopaxi.

Day 10: 14/07/19- My journey to Banos a town 130km south of Cotopaxi would take approximately 3 hours via bus. As this was a Sunday and many of the shops and villages are closed throughout Ecuador, I have chosen to make this and the 15/07/19 my rest days.

Day 11: 15/07/19- Rest day spent in the bustling town of Banos.

Day 12: 16/07/19- A short journey to Puyo, a small town 60km east of Banos where the amazon basin begins. Here I plan to visit two gardens. One being Parque Etnobotanico Omaere run by Chris Canaday an American ethnobotanist. And secondly Omar Tello's Jardin Botanico "Las Orquideas" a 7-hectare plot of land replanted to encourage diversity of plants a fauna back to the area.

Day 13: 17/07/19 - A guided tour around Chris Canadays Ethnobotanical garden learning all about the medicinal uses of the Ecuadorian flora and a brief history on local tribes, rituals and healing ceremonies.

Day 14: 18/07/19 –A guided tour around Omar Tellos' Botanical Garden learning the history of the area and how he brought I back to its 'wild' state.

Day 15: 19/07/19- A guided tour in a dugout canoe by local tribes down the Puyo river, this is a tributary of the Amazon river. Here I will be learning first-hand how the tribes have used the land to create a home for many centuries.

Day 16: 20/07/19- Travel from Puyo to Riobamba the nearest town to Chimborazo via bus and find my accommodation for the next 3 nights.

Day 17: 21/07/19- Look for the best guided tour of Chimborazo volcano in the local town Riobamba (impossible to find on the internet back in the UK) this may take half the day. The other half will be spent preparing for the ascent of Ecuador's tallest mountain.

Day 18: 22/07/19- Meet the tour early to begin the (5,800m) ascent of Chimborazo mountain, take with me field notes from Humboldt's journal that I found online to hopefully compare flora with altitude as I ascend. visit the *Polylepis* forest on the south side of mountain.

Day 19: 23/07/19- Travel to Aluasi just 120km south of Chimborazo mountain on the same longitude. Although in the same region of 'Chimborazo' this falls out of the protected shadow of the mountain and into working towns of rural Ecuador.

Day 20: 24/07/19- I intend to walk along the infamous 'Devils Nose Train Track' that hugs the mountains. Much of the land is still famously farmed by hand by locals using techniques passed down through generations. The same methods Humboldt would have witnessed when passing through the area 200 years ago.

Day 21: 25/07/19- Travel to Guayaquil where I stay for my final two nights before flying home.

Day 22: 26/07/`19- Rest day in Guayaquil before the long flight home

Day 23: 27/07/19- Fly home

Quito Botanic Garden

Figure 3 stood amongst the incredible orchid collection at Quito Botanic Garden

After a slight shift in my itinerary I found myself with an entire day at the national Botanic Garden of Ecuador, as opposed to a mere few hours which was originally planned. Brilliant! This would be the keystone to build upon for my entire trip, using the botanic gardens well labelled collection I could easily familiarise myself with the range of taxa I will be coming across on my travels. Unfortunately, there was no English-speaking tour but instead a map of the garden and my flora of Ecuador book would be the next best thing.

The garden is around 5 acres nestled in La Carolina park, although the garden is small it has huge character, one unusual feature of the garden being its 3,000m altitude, making it the highest Botanical Garden in the world. Tourists are mainly attracted to the Orchidarium where over 1,200 orchids native to Ecuador are displayed in a long-netted tunnel. This may seem a large collection however there are over 4,000 native species to the country alone so collecting is far from over for the scientists and horticultural staff. The rest of the garden is divided into regions of the country based on ecosystems; of which there are four, highland wetlands, cloud forest, moorland and dry thorn Shrubs (these are also subdivided). In addition, the Botanical Garden has areas with key ornamental features such as the Rose Garden and the Ethnobotanical Garden.

The Orchidarium

Figure 4 looking back at the Orchidarium from the viewing tower

The orchid house is a simple structure being a long tunnel with very fine mesh surrounding it, this acts as a barrier from sunlight and wind. The altitude of the garden and its exposure means its UV light is far higher than it would be under the dense cloud forest canopy, the mesh cleverly however lets in enough for the orchid's growth. It also reduces wind and helps increase the humidity inside the tunnel, this is vital for most the orchids as their natural climate is damp, humid and foggy. The collection is mainly displayed in small rock formed beds that run the length of the tunnel, any gap or crevasse is filled with what looked like a mixture of bark and peat. Some orchids are hanging in displays usually modified pots or hanging basket. Mostly everything was planted in groups with a single label of a genus such as *maxillaria*, this helped simplify the collection but also presented a large range of different flowers in a single bed. Notable genus currently in flower here were *Masdevallia, Dracula, Pleurothallis* and *Oncidium.* These would no doubt be the few Orchids I would see in flower in the cloud forest. In figure 5 you can see the distribution of native orchids throughout Ecuador, almost 70% being in the sierra (Andes).

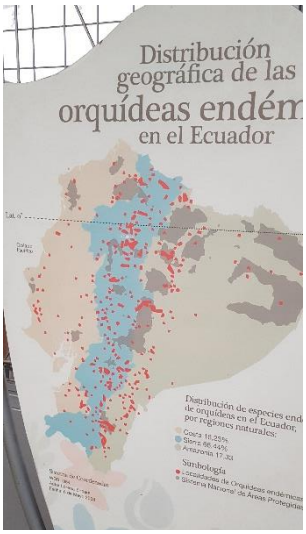

Figure 5 distribution map of Ecuador's native orchids

Santa Lucia Nature Reserve

Santa Lucia Cloud Forest is a cloud forest reserve, located about 80 km northwest of Quito, in the province of Pichincha, in Ecuador. This is at the far south of the southern phase of the Choco-Andean Rainforest Corridor. Rainforest Concern works with the Santa Lucia co-operative, a community-based conservation organisation dedicated to conservation and sustainable development. Both united so those working at the Santa Lucia lodge can make modest living whilst conserving their remaining cloud forest.

The community owns over 1,200 acres of montane cloud forest, of which about 80% is still prime, virgin state and the area has now been declared part of a Bosque Protector (Protected Forest). The community-based organisation formed by local campesino families manage their own resources and they have three basic aims:

Figure 6 Views onto the Andean Cloud Forest from the Los Cedros Lodge

1. To conserve and protect the cloud forest belonging to member families.

2. To develop sustainable sources of income for the members of Santa Lucía.

3. To benefit directly or indirectly the residents in neighbouring areas.

Figure 7 Finding shelter under the Xanthosoma undipes leaf in a downpour

The 2hour hike up to the lodge was overwhelming, every 100m I climbed the density of forest dramatically increased as well as the diversity of flora. The area Santa Lucia covered had a dramatic range in elevation from 1,200m to 2,000m. The climb to the lodge allowed me to see how elevation effected moisture, humidity and canopy density so dramatically. The 800m climb also highlighted the difficulty of constructing a conservation lodge at the top of a mountain where the only access is a muddy, narrow forest trail. Yet, maybe another reason why this location was so special! being so distant from civilisation it is currently still untouched by mining companies and foresters.

There were an abundance of certain understory species that I came across frequently at Santa Lucia that are commonly cultivate at Kew, such as the vibrant flowering *Abutilon striatum (figure 7),* several *Centropogon spp* including the most floriferous *C solanifolius,* not to mention the abundance *Araceae* including the prominent *Xanthosoma undipes* that towered up to 2m up with huge leaves, and as you can see in figure 8 they make for an ideal natural umbrella when caught in a downpour

Figure 8 The eye-catching flower of the Abutilon striatum

Identifying the tree spp in the cloud forest can be a very difficult task even in the 21st century however, new technology such as drones with high resolution cameras can now accurately classify the tree down to species level. Humboldt however would have had an entirely different situation! As I found the canopy level is 30m+ above your head which makes collecting leaf samples impossible. Occasionally a tree could be identified by its bark, this is not so easy in the cloud forest, due to the high moisture content in the air it creates the ideal climate for epiphytic plants. A single tree had 50 or more different spp using the trunk, branches and canopy like a climbing frame. Recognisable taxa I saw were *Cavendashia nobilis* var. capitate, *Columnea picta, C. kucyniakii*, hundreds of *philodendron spp, Gurania eriantha, Passiflora*, not to mention the plethora of Orchids and bromeliads peppered through the trees. Many of these

epiphytes survive solely on the moisture in the air, this is captured by the adventitious aerial roots. many plants tap into the moisture retained in the bryophytes of the forest; liverworts, mosses and vascular clubmosses. Seeing first-hand the affect that epiphytes have on reducing evapotranspiration was eye opening and something I could never fully grasp in Kew Botanic Gardens climate-controlled glasshouses. Looking onto the next 10 months at Kew I hope to use this insight in areas such as the orchid festival in February, I hope I can add to the presentation of the orchids using gymnosperms such as *Blechnum occidentale, Nephrolepis sp* and the unusual climbing *Microgramma* that may help create a naturalistic look to the display.

Los Cedros Nature Reserve

Los Cedros Biological Reserve consists of 17,000 acres of premontane wet tropical forest and cloud forest. Of this, 2,650 acres is formerly colonized land, while the remainder is primary forest. The reserve is a southern buffer zone for the 450,000-acre Cotocachi-Cayapas Ecological Reserve which also covers Santa Lucia, both are part of the Choco Phytogeographical Zone. The Choco region is one of the most biologically diverse and endemic habitats on Earth.

Figure 9 The densely crowded canopy of the Andean Cloud Forest

Arriving at the trail head of Los Cedros on the 9th of July I met two welsh students who would also be staying at the lodge, they were traveling in Ecuador working in varies reserves studying the diversity of fauna. The Los Cedros reserve has been a vital place for students and scientist to base their studies since 1988 when the reserve opened. Later that day two entomologists from England and two American science teachers joined us at the reserve. There would be no guided tour of the reserve until the 11th.

Immediately I found Los Cedros to have a far wider range of flora than Santa Lucia, the elevation of the reserve ranges dramatically from 1,000m up to Cerro de La Plata at 2,700 meters. This is the last ridge in the Cordillera de La Plata, our guided tour would take us there on the 11th to observe the damages local mining companies had supposedly done. Hiking through the reserve on the 10th with entomologists and zoologists gave me a far larger insight into how the forest functions as an interconnected ecosystem. The interaction of plants, insects, bats and birds became more apparent the further we hiked and the more we saw.

The cloud forests of Ecuador typically contain many families of plants that are unrecognisable to a gardener, I found myself learning new genera and Family names daily such as *Melastomataceae* and *Marcgraviaceae*. A surprise then was coming across the Ericaceae family. Its normally distinct bell-shaped flowers that can be seen on commonly cultivated spp such as the *Arbutus unedo* and *Pieris* japonica was what you'd normally expect….

Figure 10 Thibaudia sp with a dissected flower and Cavendishia sp

Finding these endemic *Ericaceae* spp (above) highlighted how flower morphology and many other characteristics are moulded by the interaction these plants have with their environment both biotic and abiotic. As you can see in figure x & x the infamous bell shape of the *Ericaceae* is lost with the elongation of flower parts. This is thanks to one of Ecuador's most important pollinators, the hummingbird. Both the *Thibaudia* sp and *Cavendishia* sp (figure 10) are hummingbird pollinated plants which explains the elongation of their petals, filaments and style which is clearly seen in fig x where the flower is dissected down the centre. Humboldt theorised early concepts of evolution in his work by highlighting how ecosystems function as a 'web of life' where each thread on the web plays a vital role to balance and strengthen the natural world. Humboldt wrote in an early diary "in this great chain of causes and effects, no single fact can be considered in isolation" (Mark W.Person, 2014, Views of Nature Alexander Von Humboldt). Although Humboldt didn't question how hummingbirds may have manipulated the adaptation in flower morphology of these *Ericaceae*, he was on a very similar vein of thought. Humboldt's concept that nature "lives and moves and weaves into a whole! Each part gives and receives" (Andrea Wulf, 2016, The Invention of Nature) was revolutionary in the early 1800's and it laid the foundation for future scientists like Darwin to create the theory of evolution.

Identifying flora with the aid of keys, books and prior notes I made from Kew's vast range of south American plants made my task slightly easier. In contrast Humboldt had very little scientific publishing's to fall back on when identifying a species. Flowers and their anatomy are crucial in angiosperms, finding them gives you the golden ticket for identification. I came across a breadth and depth of impressive flowers while stumbling through the foggy mountains. Being such a crowded place flowers in the cloud forest need to stand out in order to attract their pollinators, especially those that are pollinated by hummingbirds as sight is their main sense.

Figure 12 Brunfelsia grandiflora, Bomarea pardina, Grias cauliflora, Passiflora sp and Burmeistera cyclostigmata

Figure 11 Early morning views through a clearing in the canopy as I left for Cotopaxi

Cotopaxi Nature Reserve

Leaving the Cloud forest on the 12/07/19 I journeyed towards Cotopaxi volcano. This was in fact almost the exact date Humboldt attempted to climb the volcano on the 23rd of June 1802, Humboldt described the volcano "as if a wood turner had created it on a lathe" (Andrea Wulf, 2016, The Invention of Nature p.84). Unfortunately, throughout my 3 days at Cotopaxi the mountain was almost always shrouded in fog, I still however managed to venture into the reserve and as far up the mountain as my legs would take me. Humboldt highlights in his diary the drastic change in flora as he ascended Cotopaxi, above 14,000 ft the trees and shrubbery became smaller until they reached the so called Paramo (a treeless alpine plateau of the tropical Andes). Beyond this point the tufted brownish *Calamagrostis intermedia* grass that covered the higher elevations of the mountain gave the landscape an almost barren look. Humboldt mentions the illusion that this area is lacking diversity, the misconstruing grass hides what is only found at closer inspection. The ground is covered in minute colourful flowers of all kinds. The images below give you an idea as to how difficult some of these are to spot due to their size and obscurity.

Figure 13 (a,b,c) Hypericum laricifolium, Werneria nubigena and Valeriana rigida right

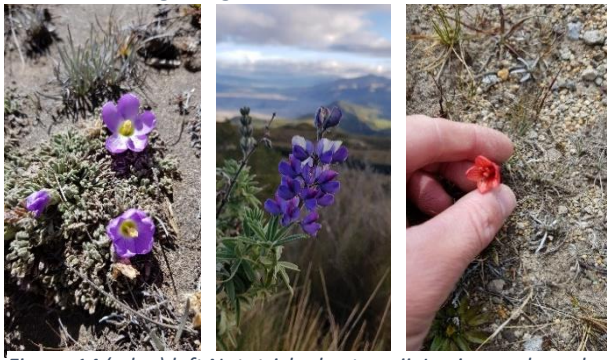

Figure 14 (a,b,c) left Nototriche hartwegii, Lupinus pubescebs and Gentianella cernua right

Unlike the large and bold flower morphology of the Cloud forest plants these are small and inconspicuous in comparison. The elevation, temperature and soil type all effecting the size and form of the plants, in addition the environment affecting their pollinators which are most likely small insects, therefore no need to stand out to attract the likes of hummingbirds. Elevation, temperatures, rainfall and humidity were all key measurements Humboldt could use to link not only the change in flora, but also the species of fauna at different altitudes and how they were all linked together. Humboldt's famous drawing of Naturgemälde (meaning a 'painting of nature') based on Ecuador's Mt Chimborazo, explains Humboldt's concept of nature as a unified globe with corresponding climate zones across the world (see page 16 for further detail).

Before exploring the Cotopaxi reserve, I made several notes from Humboldt's journal of Ecuador 'Views of Nature'. I thought I would be challenged to come across just some of the plants Humboldt noted down, I found that I saw almost all the species he came across. He writes "I found small lupins (*Lupinus pubescens*) and tiny gentians which formed soft, moss-like cushions. *Valeriana* dots the landscape with its white centre held tightly within a rosette of green leaves". *Lupinus pubescens* (figure 14.b) were abundant on the mountain as were the *Valeriana rigida* (figure 13.c). other notable finds were *Gentianella cernua (*figure 14.c), *Werneria nubigena* (figure 13.b), *Hypericum laricifolium* (figure 13.a) and finally the endemic *Nototriche hartwegii* (figure 14.a)

Parque Etnobotanico Omaere- Chris Canaday

The study of flora is the priority in Omaere park. It covers 15.6 hectares, of which 5 are primary forest (natural forest that has received no human intervention) where we can also find a strong diversity of plant species and animals. The remaining 10 hectares are secondary forest cut down in the 80s for timber and land use. The Ethnobotanical Omaere Park does not only concentrate their efforts in Botany. One of its objectives is also to help fortify the cultures of Indigenous nationalities of the region, Chris and his wife are the fountain of knowledge that spearhead the educational side of the park. It was originally one of the first ethnobotanical gardens to open in Ecuador, hopefully many others will follow in the idea which may help to conserve not only the biodiversity but also the local indigenous knowledge that is being lost as fast as we lose our forests.

Chris began the tour by telling me about the local tribes of the Puyo area and beyond into the Amazon basin, there were two main tribes locally to the town: The Waorani tribe and the Shuar tribe. The lifestyles of these indigenous people have changed drastically over the last 100 years with the increase of tourism to the area, people like Chris have studied and lived alongside these tribes for many years to understand their way of life.

The Waorani tribe may be most famous for their use of the Waorani Blowgun, their primary tool for hunting monkeys! The blowgun is made from a split palm wood rod; the two halves are grooved then reattached with beeswax. Darts are created from the whittled stems of palm leaves and stored in a bamboo quiver. A potent neurotoxin is added to the dart to relax the muscles of the monkeys, causing them to drop from the branches onto the ground, this toxin obtained from a vine that grows abundantly in the Amazon basin called *Strychnos toxifera*. The less potent end of the dart was wrapped in fluff that surround the seed of the *Ceiba petandra*, this filled the inside of the blowgun to push the dart out towards its target at high speed.

Both the Waorani and the Shuar tribes both relied on the Amazon Rainforest as a lifeline, they sourced everything they had from the plants that surrounded them even their medicines. Chris began to explain how the Shuar tribe used a palm called *Bactris gasipaes* to make a beer, however with a very strange twist. The red fruit that is produced in abundance in the tree would be harvested, then cooked in hot water to soften it up. Next, they would chew the fruit up in their mouth to turn to pulp and after spitting it out into a bowl. It would then be left to sit for days where the saliva released from their mouths would break down and ferment the fruit, before finally extracting the juiced to make the beer.

Chris carried on by highlighting the importance of protecting what is left of the amazon for those tribes not willing to reach contact with the modernised world. He also stated the importance of the tribes we have communicated with, learning the way they use plants ethnobotanically may be an insight for future break throughs in medicines. Below I have included a few plants I found interesting, the *Gesneria* (figure 15) can be crushed and the juices used to sooth bites and stings. The *Genipa americana* as shown in figure 16 is a plant used for tribal face paints, the orange stem of the plant pours out of the stem when cut, the sap then stains the skin for several days (as seen on my hand).

Figure 15 Gesneria sap to rub into bites on the skin

Figure 16 Genipa americana sap for tribal face painting

Jardin Botanico “Las Orquideas”- Omar Tello

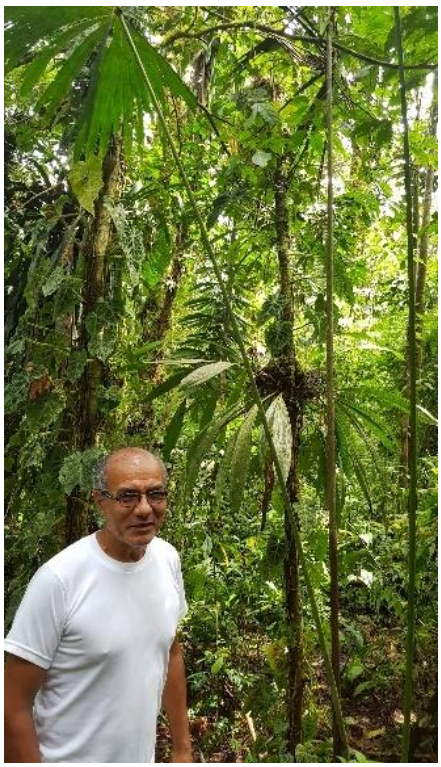

Figure 17 Omar Tello

The story of Las Orquideas started when Omar Tello quit his job as an accountant in 1980 in order to follow his dream of creating a forest out of an abandoned pasture, that was once a rich thriving forest. Today, 40 years later, the reserve is self-sustainable from tourist entrance fees. He has received enough private donations to build an interpretative museum and classroom and receives students from Ecuador and abroad such as myself to study the incredible change he has implicated on the land.

Las Orquideas is only 1 mile from Chris Canaday’s Ethnobotanic Garden yet upon arrival It felt like it held a very different motif. Omar had bought the land in a drastic attempt to restore the now shrubland back to a thriving forest. What Omar didn’t have that the Ethnobotanic park did was an already established primary forest, making the task uphill from day one. Omar explained that to restore the infertile soils he first began by buying huge bulks of sawdust and chicken manure to incorporate the nutrients back into the soil so that the plants would quickly establish. He massively overplanted with tree species such as *Schizolobium spp, Jacaranda copaia, Cedrela spp, Swietenia macrophylla* and *Tabebuia spp* to quickly form a canopy. After 10 to 15 years as the canopy lifted Omar quickly began to thin out certain trees and plant understory flora to increase diversity.

Now, after 40 years he now has a fully established forest, his collection of orchids is extremely diverse. Omar has been visiting recently felled woodland throughout the region for 30 years saving any precious epiphytes and returning them to his forest where they will be safe. To call Omar a sharp-eyed Horticulturists is an understatement, his ability to spot orchid flowers as small as a fingernail in a dense forest was immense. Below are just a handful of orchids we saw there. A separate word document will be attached in the references with photos of all the flowing Orchids I spotted through Ecuador.

Omar concluded with a tour of the nursery collection, mostly full of orchids of all kinds and other various plants such as *Heliconia* spp and *Aristolochia* spp. He briefly showed me the small museum packed with images and dried insects’ specimens collected from the woodland after 60 years of their absence. With insects followed mammal’s caught on Omar’s camera traps, highlighting the impact of forest ecosystems and the interconnected ‘web’ that is created in these forest biomes.

Figure 22 Platystele sp

Figure 22 Lepanthes sp

Figure 22 Lepanthes sp

Figure 22 Specklinia sp

Figure 22 Scaphosepalum sp

Chimborazo Mountain

Figure 23 Bomerea hirsuta

On the 22nd of July I met my guided tour in Riobamba and drove first towards the lower steppe of the Chimborazo national park. Humboldt first described the mountain in July 1802 as a 'monstrous colossus', that is exactly what it was rising 6,268m above sea level, it is Ecuador's tallest mountain. What is so unique about chimborazo is the species richness and range of climatic zones, on the approach to Chimborazo you pass thick tropical vegatation. Here I spotted *brugmansia sanguinea* which Humboldt noted as *a Datura spp, e*ye catching Bomerea hirsuta (figure 23) and Passiflora mixta (figure 24), these volumptous blooms were soon to be replaced at between 2000-3000m with temperature and moisture dropping. Here we started to enter a far more temperate climate, with high winds, solar radiation and cold temperatures the plants at these altitudes are highly adapted.

Figure 24 Passiflora mixta

After rising up above the tree line (or so what we thought) at 3,500m the vista opened up to reveal the mountain in all its glory. At this point the vegetation was mostly *Calamogrostis intermedia (figure 26),* however scatted amongst rocks and between tufts of grass there were hidden gems. A plant abundant through the park was the *Chuquiraga jussieui* (figure 24) my tour guide mentioned its use as a treatment for altitude sickness, this was very coincidental considering it only grows above 3000m.

Figure 25 Chuquiraga jussieui in the foreground of Chimborazo

Figure 26 Calamogrostis intermedia glades surrounding the foothills of Chimborazo

As you can see in figure x the grassland covers the steppe up to the foot of the mountain, being a protected park, a very rare mammal freely inhabits the grassland, the vicuñas (figure 28). These are the largest of the wild Lama's of the paramo. They need very little water and can live in semi-desert areas. A peculiarity of this animal is that its incisive teeth grow during most of its life, allowing them to feed on tough leaves.

Figure 27 The Vicunas grazing around the nature reserve

Figure 28 Puya clava-herculis and flower

This *Puya clava-herculis (figure 27)* is a species I've seen cultivated at Kew under the glasshouses, to see it in the wild highlights its hardiness and durability, undoubtedly a species we could be looking to cultivate outdoors in the gardens. Its vibrant blue flowers that emerge from the 1-2m inflorescence stand out in the bleak backdrop of the dark volcanic rock.

The extremities of the environment cause drastic adaptations in the plants, particularly dwarfing. *Werneria pygmaeais* (figure 31) an example, they grow in cushions as a response to these difficult climatic conditions growing solely off the rock and therefore are xerophytic. Growing beside the *Werneria* I found a flowering *Halenia weddeliana* (figure 29) with its brilliant yellow reflexed flowers.

Figure 29 Halenia weddeliana

Figure 30 Espeletia garcibarriage

The *Espeletia garcibarrigae* (figure 30) near the entrance of the reserve is a Colombian species, not native to Ecuador. Humboldt had mentioned the presence of "Frailexon" but there are no indications they ever grew there. Apparently, some biologist reading Humboldt's journal felt it should be "re-introduced", but it is a non-native foreign species. Yet, it is very pretty around the visitor centre.

Figure 31 Werneria pygmaearis


Figure 32 The enchanting Polylepis forest at 4,000m in elevation

The evergreen high montane *Polylepis* forest in Chimborazo only exists in a handful of areas. The one I visited beings a small 1 acre south facing slope of a gully, these *Polylepis reticulata* grow at the high elevations between 3,000-4,000m making it the highest forests in the world. In these forests, forest floor tends to be covered by a dense layer of moss. The trees are gnarled, with trunks branched and, in some cases, very inclined or almost horizontal trunks. The images above give you a brief idea of their contorted habit. The growth is predominantly at a 45-degree angle to protect itself from the wind and harsh weathers, keeping below the ridge of the hill is vital for the tree's stability. The decline of the woodlets are prominent in Ecuador and throughout the Andes, work is being done to protect this species and many other IUCN plants listed as endangered. Loss of these beautiful trees is due to several reasons, mainly deforestation for grazing but also the increase demand for timber. For generations, indigenous peoples have used the slow-burning, dense wood to heat homes, cook food, make wooden handles for tools, and to build corrals for grazing animals. They also use *Polylepis* bark to dye cloth and to help treat respiratory illness and kidney disease. Another downfall is the rate of growth, at the highest elevations, this slow growing tree can take more than 160 years to grow a half-inch in diameter.

Figure 33 Gentiana sp

There are very few locations in Chimborazo National park that I wasn't vulnerable to bitter cold, thin air and high levels of sun exposure. Under the canopy of the *Polylepis* was the only exception, it trapped moisture, blocked solar rays and diverted fierce winds. This therefore allowed other plants to colonise the understory, the *Gentiana* sp (figure 33) and the *Bomarea* sp (figure 34) are perfect examples of this with next to no chance surviving outside the comfort of the grove.

Figure 34 Bomarea sp

It was here in Chimborazo that Humboldt created the first and most stunning depiction of nature as an interconnected whole, the so–called Naturgemälde – a German term that means 'painting of nature' but which also implies a sense of unity or wholeness. It was, as Humboldt later explained, a 'microcosm on one page'. (see figure x)

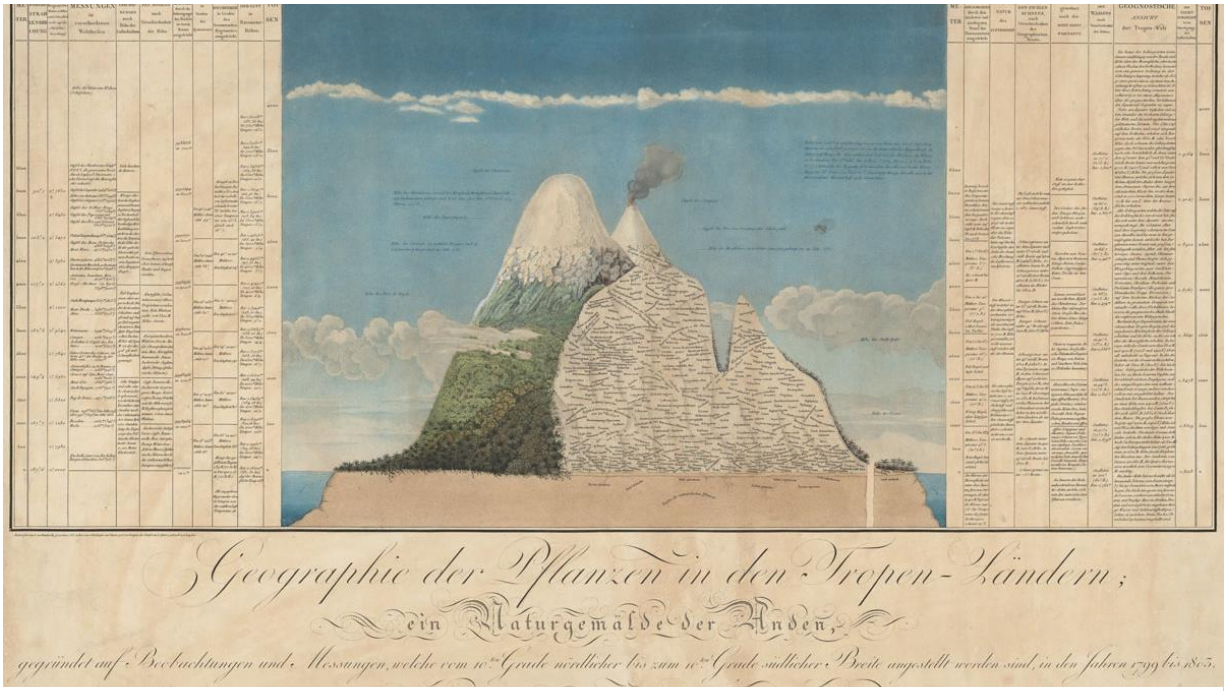

Figure 35 Humboldts Drawing of Chimborazo "Naturgemälde"

Humboldt created this three–foot by two–foot Naturgemälde (figure 35) depicting Chimborazo in 1802. The cross–section of the volcano showed plants distributed according to their altitudes. To the left and right of the mountain he placed several columns that provided related details and information, ranging from temperature, gravity, and humidity to the blueness of the sky – again all related to the height of the mountain. Humboldt showed the relationship between the elevation and the distribution of plants, before this time correlations between altitude and the flora was very uncommon, especially depicted in one “infographic”.

As I climbed Chimborazo, I attempted to find the last stand or collection of a various plant species, this as Humboldt first observed was a correlation to the climate at that altitude. I didn’t use large scientific equipment as Humboldt to take measurements of altitude or humidity etc. However, an altitude app on my phone along with my expert mountaineering guide, would tell me the rough height above sea level. On the southwest side of Chimborazo, Humboldt observed the limit for vascular plants between 4,700 m ~4,600-m. I climbed to 5,500m and found many Hypochaeris spp at altitudes exceeding 5,000m, other vascular plants such as Perezia pungensand espeletia pycnophylla. The highest vascular plant I spotted was the Culcitium canescens at 5,400m almost 700m above the limits of vascular plants humboldt stated in 1802. Humboldts Naturgemälde is used by scientists and botanist today to reference this drastic altitude shift in flora, it is a fantastic source of knowledge to highlight the effects of global warming. As Ecuador is on the Ecuator it has experienced rising temperatures, such an event leads plants to colanise higher and higher altitudes to escape the warming temperatures, which is exactly what we see today on chimborazo.

Seeing this in person has been incredibly eye opening for my view on climate change and how much control we have over it. As a horticulturist I desperately want to preserve what we have left of our natural habitats and the ever deminishing native flora that enhabits these areas. It highlights to me the important work Kew can do to conserve many endangered plants most pominantly the IUCN Red listed flora. It also raises the crucial work people like humboldt did to carve a way in understanding our natural world, constantly refering to observations made over 200 years ago may shine a light on our current situation, even answering unsolved questions such as the state of our deminishing polylepis forests.

Alausi- The Devils Nose Pass

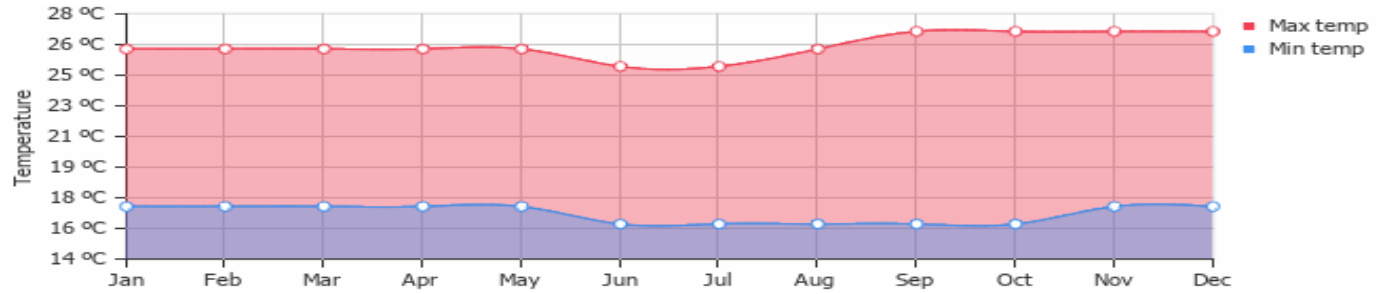

Figure 40 Temperature graph of the Alausi area

Figure 37 Tillandsia sp

Figure 36 Buddleja sp

Figure 38 Salvia sp

Figure 39 Opuntia soederstromiana

Alausi lies 120km south of Chimborazo mountain, at the southernmost point of the Chimborazo province. The reason I picked this location to visit was due to its difference in the climate to any other location I visited in Ecuador. There are many different factors such as altitude, precipitation and temperature that cause the semi-desert climate in a small pocket of the Andean mountain range. This occurs in the lower portions of most inter-Andean valleys, where precipitation is reduced due to the "rain shadow" effects of the surrounding high mountains. Annual rainfall in these deep, arid valleys is generally less than 300 mm. As seen in figure 40 the minimum and maximum temperature over the year range between 16°c and 27°c, this combined with an average monthly rainfall of 150mm (compared to Puyos 500mm) gives a perspective of its relative aridity. These dryer and sunnier conditions give rise to plants more adapted to less water such as the Buddleja sp (figure 38), Salvia sp (figure 39) *Opuntia soederstromiana* (figure 40) and the dry loving Tillandsia sp (figure 37)

A majority of the landscape around Alausi are farmed by hand and the techniques used are unchanged since humboldts visit in 1803, the Quechua people have continued their methods passed down through their ancestors to maintain their identity and culture. The land farmed is extremely treterous with shear cliffs and steep slopes all intergrated into the land shared between families. They sow and harvest the land by hand, some using cattle to plough the fields. They harvest crops using sickles and scythes, I saw this in Alausi with hundreds of people dotted across the hillside in their brightly coloured handmade clothes. The endemic flora of the area was dotted between patches of land and scattered amongst the rock faces, still vibrant with life which is an integral part of the Quechua peoples culture to maintain and respect the land. It was interesating to find such an orray of flowering plants (as seen below), especially when their identity remains so allusive from my flora of ecuador book.

Figure 44 Solanum sp

Figure 42 Asteraceae unknown

Figure 41 Unidentified Orchid species

Figure 43 Iochroma sp

Summary

Through my 3 weeks of traveling the length of Ecuador's Andean Mountain range I saw a vast range of climatic zones from the Temperate regions of Cotopaxi and Chimborazo, to the Mediterranean zones through Aluasi, the Tropical Amazon of Puyo and the montane cloud forests of Santa Lucia and Los Cedros, within them a breadth of taxa could be found. In summary, the goal for myself with this experience was to understand the range of Habitats that plants inhabit and how they do so, Compare the flora Humboldt encountered with that I saw while following his exact journey. And finally use this experience to form a backbone of knowledge to hopefully benefit Kew, myself and the various nature reserves and botanic gardens that I visited.

I believe with the knowledge I obtained through this Scholarship will benefit me greatly in future work in the various Glasshouses. I have already found this to be so whilst working in the newly refurbished Temperate glasshouse, I have been given the South American beds to care for from August to December. Whilst under this placement I found myself caring for *Bomarea spp, Brunfelsia sp, Abutilon striatum, Puya clava-herculis, Malvaviscus pendiflorus, Tibouchina sp* and many others, ex-situ in a glasshouse these plants require very different care such as watering, feeding and pruning. To have seen these plants in the wild is extremely helpful in cultivation, half of the task when growing plants in a highly controlled environment (Temperate house) is knowing what each plant desires, and my job is attempting to recreate their natural habitat as closely as possible.

Whilst following Humboldt's exact expedition through Ecuador I have stumbled upon many interesting insights, not only learning how he viewed the natural world but also see the drastic change of Ecuador's landscape over these 200 years. Humboldt travelled mainly by foot, mule or boat which is slow, however, the terrain of what was then untouched made everything even slower. Of the 5 years spent travelling the Americas, Humboldt and his team spent 32 months in Ecuador which is more than ten times the number of weeks I had to travel the same distance. This is mainly due to the rapid change in infrastructure; roads, towns and cities have all flown up making most areas of the small country accessible. With this has come destruction of habitats. I found almost every location I visited had some degree of habitat destruction and loss of plant diversity. Whether it was mining for grit in Cotopaxi to make cement, or the felling of *Polylepis* in Chimborazo for firewood, logging in the Amazon for timber, destroying Montane cloud forest for mining precious metals, even simply disregarding the landscape to build the Pan American Highway. Destruction of habitat and extinction of plant species has been rife throughout Ecuador since Humboldt visit, and it should at this point change is made to conserve what is left.

Meeting conservationist such as Omar Tello, Joseph Decoux, Holger Beck, and Chris Canaday has brought a hopeful perspective on the future of Ecuador. Through their hard work they have all created pockets of protected land for scientist, horticulturist and students to learn what untouched insights they may have to offer. I have learnt so much about ecology, conservation and flora from this group of conservationists and the many other students I encountered, this knowledge will hopefully stick with me through the rest of my career in horticulture.

Future Plans

After visiting Ecuador, I found the things I learnt on the trip would come into use far more quickly than I predicted. Working in the Temperate Glasshouse I was immediately using my knowledge in a practical setting, which is exactly what I hoped for and without it I believe it would have been a very difficult learning curve un the 4 months in that placement. It made the transition into my first experience in a Temperate Glasshouse setting very seamless. For example, in a busy location such as Kew you receive a multitude of questions. Knowing information about certain plants such as the popular Abutilon striatum I saw in Santa Lucia allowed me to comfortable answer the questions that were frequently asked.

My next placement in Kew Botanic Garden will be in the Tropical Nursery, specifically working with *Araceae*, this will be another placement I can use some of the knowledge I gained to not only help me cultivate the plants but also give insight to others. To learn and compare our cultivation techniques with that of Quito Botanic Garden or Omar's small nursery will be very informative, I can use my weekly journals that I write up to look for improvements for both us and the reserves and botanic gardens back in Ecuador. Sharing knowledge is vital for conservation and protection of ever more endangered plants, I also hope I can share the contacts I have made with Kew whether it be future students that want to visit Ecuador, or our own horticultural staff looking to go on plant collection trips.

Soon after returning from Ecuador I also visited Berlin, this was home for Humboldt for many years. Whilst I was there an exhibition on Humboldt was held at the Berlin Natural History museum, it looked back on his years studying Geology where he collection thousands of rock specimens contributing to Berlin now having one of the largest collections in the world. Visiting this exhibition blew me away at what impact Humboldt has had throughout the world of science, yet astonished that his name is so forgotten. I hope to study Humboldt further to learn more about that era of travelling and collecting, his observations are so crucial and can be yet influential to horticulture and the sciences.

Budget Breakdown

Budget Breakdown	Cost	Running Total
Flights, Transport and add ons		
Flights	£1,264.99	
overpack baggage on return flight	£50	
Busses, Taxi and private transport	£300	
		=£1,615
Accommodation		
2 nights stay in the secret garden youth hostel	£55	
2 nights in Santa Lucia Lodge	£125	
3 nights stay in Los Cedros Lodge	£150	
2 nights stay in Cotopaxi hotel	£90	
2 nights in Banos	£80	
4 nights in Puyo	£200	
3 nights in Riobamba	£200	
2 nights in Aluasi	£70	
2 night in Guayaquil	£100	
		=£2,685
Food	£500	
Jabs	£353	
Entry cost to Quito Botanic Garden	£9	
Gifts	£50	
		=£3,591
Tours		
Day tour of the Amazon down the Puyo river	£70	
Day tour of Chimborazo with private tour and 4X4	£150	
Private tour of Chris Canaday and Omar Tello's Reserves	£20	
		=£3,835
Unforeseen costs		
Portable charger	£40	
Pharmaceuticals	£50	
Luggage plastic wrap	£29	
Data Sim card (needed for navigation etc)	£40	
Final Total		=£4,000

Acknowledgments

I would like to thank the following people and charities for making this Travel Scholarship possible, without there generous donations or hospitality I would not have experienced this incredible opportunity:

- I would like to thank The Royal Botanic Gardens, Kew for the opportunity to have 3 weeks out of work and study to participate in my Travel Scholarship to Ecuador.
- Martin Staniforth and David Barnes who both gave recommendations and approval of the Scholarship proposal.
- Thank you to the RHS Coke Trust Bursary Fund for their generous donation of £2,300 to support my scholarship.
- Many thanks to Merlin Trust for their Donation of £1,500 to support my Scholarship
- Thank you to The Hardy Plants society for supporting my Scholarship with their generous donation of £500.
- I would like to thank Holger Beck for his assistance and Hospitality at Santa Lucia Nature Reserve.
- Jose DeCoux for his hospitality and insight to the work being done at Los Cedros Nature Reserve.
- Chris Canaday and Omar Tello for their wonderful tours of their reserves and their knowledge and insight in conservation.
- Thank you to the Chimborazo nature reserve team who provided transport and a tour guide to view Chimborazo reserve.
- And finally, thank you to those who supported my Scholarship as references.

References, Bibliography and appendices

Appendices:

A Link to The Flowering Orchids I found in Ecuador:

Orchids of Ecuador link: https://rbgkew-my.sharepoint.com/personal/t_shaw_kew_org/Documents/ecuador/Orchids%20of%20Ecuador.docx

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