Cultivating Highland Nepenthes

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Preface

Like many others, my fascination with carnivorous plants started in childhood, I still remember the day I first saw one of these plants, tagging along with my mother to a local plant show when I was 5 years old, I never expected to see something that would impact the rest of my life. Sitting on top of a small booth were plants unlike anything I had seen before, amongst pots of the classic Venus fly trap sat small rosettes with glistening dew, and others with tall white mottled pitchers. I left the show that day with a Drosera spathulata and a Sarracenia leucophylla and the spark of a new interest growing inside me. While I'm certain I gave these first two plants improper care and killed them fairly quickly, I've spent the years since growing many genera of these wonderful plants and honing my skillset before later focusing on the genus Nepenthes. When most kids were playing videogames, I was in the basement working on terrariums, and instead of asking for sporting equipment or a new phone for Christmas like most of my friends did, for my 15th birthday I asked for a grow tent and lights. I had that first small tent as well as a chest freezer setup for 7 years, managing to fit nearly 300 plants between the two. Being in the hobby for so long has allowed me to build up relationships with so many growers both near and far through places like Terraforums, Facebook groups, and my local plant club, and without these people I wouldn't have had the opportunity to grow nearly as many plants as I have. I am so thankful for the people who were willing to give the "bright-eyed kid" a chance, those who gifted me plants, traded with me, and helped me find rare species which I could never get on my own. At this point in my life, I have had the rare opportunity to grow the vast majority of Nepenthes species and have had experience with hundreds of individual clones and crosses. I hope that through this guide I can assemble the knowledge I have gained over these years into a format that can help those that are like my younger self, people who have the dedication to learn about these plants and spend the years it takes to grow Highland Nepenthes to maturity.

My first Highland Nepenthes setup in my childhood bedroom, using fish tanks, fluorescent lights, and an HVAC tube to deliver air from a partially open window into the tanks.

Nepenthes lingulata

Intro

Teeth as sharp as a knife, fur like that of a mink, and pitchers that not only look like a toilet but function as one too; these are just a few of the traits that make Nepenthes, the tropical pitcher plants, among the most intriguing plants to anyone who lays eyes on them. While all carnivorous plants are fascinating, Nepenthes are above all others, because in addition to their advanced carnivorous methodology, their pitchers are completely unique among plants as a novel leaf structure that grow independently from the main photosynethic leaves. The genus Nepenthes is also one of the most phenotypically diverse among all carnivorous plants, and while its distribution is limited, in the countries where these plants are found, they grow in many diverse ecological niches from hot lowland forests to alpine mountainsides.

Left: Nepenthes spectabilis; Right: Nepenthes undulatifolia and hamata

Highland Nepenthes (highlanders) are cool-growing species, often defined as species that grow above 1500 meters in altitude, while species that grow above 2500m are often referred to as “ultrahighlanders”. These species can be found across southeast Asia, from the island of Sumatra all the way to Papua and everywhere in between, but even with this diversity their general cultivation is much the same. These plants were the eye candy of the Victorian-era upper class, but thanks to modern advancements they are now available to everyone with a desire to connect with nature, and with the patience to cultivate these marvels of the natural world. And these plants certainly do require patience, they are among the slowest growing lianas, requiring precise conditions across many years to reach maturity. This guide will cover what those conditions are and how any grower, beginner to expert, can provide them; we will also discuss other important details that will help you along in your journey to success with growing highland Nepenthes.

Cultivation

If I had to summarize highland Nepenthes cultivation in one line it would be "bright light, high humidity, pure water and soil, warm days, but above all else, cold nights". People often downplay how important these conditions are for Nepenthes, especially nighttime temp drops, and while it is fun to experiment with your plants and some species certainly can be adapted to warmer conditions, it is very clear to anyone with experience in these species, that too-warm conditions are the number one killer of highlanders. This begs the question; what temperatures do these plants require and how do people provide them? This question will be answered later in this section, but first we will go through the other conditional requirements of highland nepenthes, many of which are the same as those required by both lowland and intermediate species.

Nepenthes lowii x tentaculata lower pitcher

Soil

Nepenthes are tropical lianas, and unlike many other carnivorous plants they are not bog plants, so rather than waterlogged soils they are often rooted in moss, loose rocky media, or even epiphytically on trees. In nature these medias are aerated by frequent rainfall and lack many of the nutrients that one would find in average garden soil, so how do we match these traits in cultivation? To understand this, we first need to look at what happens when the wrong media is chosen, media that is too dense or wet can cause root rot which spreads quickly and often kills the plant before you notice an issue. Media that has too many nutrients can cause pitcher production to stop or in severe cases cause growth to slow and new growth may even burn. To avoid these issues we need airy, nutrient-free media, that is easily accessible and if possible, affordable. The most common choice is sphagnum moss as it is what many species grow in naturally, and it is easy to source due to its use in the orchid trade. Sphagnum moss is airy and loose when fresh, it lacks nutrients and does not get easily waterlogged, but it is still advantageous to use aggregates such as pumice or perlite to keep the media airy and free draining over time. While sphagnum is one of the most used

medias for Nepenthes, it is not what I generally use or recommend, as it can suffer from quality issues and at times it can be expensive or hard to find. For these reasons I recommend the use of a sustainable product, which is made from chopped up waste husks from coconut plantations, “coco husk chips” as they are commonly sold as, have all the benefits of sphagnum while they also last longer, and are airier and more free draining, to the point that root issues are often a thing of the past. I find about 90% of highland nepenthes species do best in coco husk out of all medias I have tested, but there do remain some species that for one reason or another seem to do better in another type of media altogether, mineral based media. For the species that are naturally found in loose rocky medias, those that are more susceptible to root rot, and those that have more extensive root systems mineral media can be the perfect solution. Mineral medias such as Kanuma and Akadama strike the balance between root permeability, airiness, and water retention, they can also be mixed with other medias like pumice or lava rock that further increase airiness. It is important to note that while pumice and lava rock can improve soil quality when mixed with coco or mineral mixes they are not appropriate for use on their own as soil media for nepenthes as their hardness reduces root permeability, and they are also lacking in water retention. There are a host of other medias that people have experimented with over the years, from peat all the way to left field options like shredded rubber, and while these may work for some people, I would only advise people to try different options at their own risk, once they are more experienced with Nepenthes care.

Nepenthes Jacquelineae

Water

Watering may seem like the most basic part of cultivation, but like other carnivorous plants Nepenthes require very pure water. While Nepenthes are less sensitive to dissolved solids (TDS) in water compared to some genera like Dionaea, they still do best when TDS levels are below 50ppm. It is important to

note that while Nepenthes are less sensitive to TDS levels, not all dissolved solids act the same, calcium and magnesium for example may be safe for Nepenthes while things like iron and copper even at low levels can cause harm to your plants. There are many methods of providing adequate water to your plants, you can use rainwater (assuming its clean and not contaminated), buy distilled water, or even install a reverse osmosis system, all of these sources will have TDS levels well below the 50ppm requirement and often they will approach 0ppm. My preferred method is using a reverse osmosis (RO) system, this method requires some initial setup and does have an initial cost however even small systems produce enough water for hundreds or thousands of plants, each day. A system like this will start at 50-100$ and may require some simple plumbing, or access to a water faucet with a hose attachment, and you will then need to consider how to store the water produced, this can be as simple as gallon jugs, or for larger collections, storage tanks with automatic float valves. For small collection that don't require as much water as an RO system produces, purchasing distilled water from a store can work well, but if convenience is important, then using a Zero Water pitcher may work better, Zero Water brand pitchers have specially designed filters that work just as well as an RO system but at a much smaller scale, producing about a gallon a day, although one limitation is that these filters need to be changed frequently. Another option that some people will mention is a home distiller, these are small countertop units which use heat to evaporate water and then condense it as a purification method, these systems produce adequate water, but they are extremely inefficient and are generally overpriced compared to your other options, so I never recommend them.

Nepenthes tentaculata, speckled Sulawesi form

Now that you have got your pure water the next step is learning how to properly water your plants, remember that unlike many other carnivorous plants, Nepenthes are not bog plants, so they require much less water than other genera. Watering Nepenthes is a balancing act, too little water and the plant can desiccate, while too much water can cause rot, it takes a bit of trial and error before you get your hand at it but eventually you will be able to quickly tell

whether any of your plants need water. I recommend keeping plants a bit on the dry side as desiccation is easier to fix than rot, and given that soil media becomes lighter when dry, an easy way to tell when to water plants is by lifting the pot up and feeling how heavy it is. Once you gain experience with your plants and your exact setup you will get in a pattern, such that you may water all of your plants once a week for example, being mindful while potting your plants and picking an appropriately sized pot helps with this as well. Another consideration is how to water, some people use misters, some top water their plants, and others keep their pots in trays and fill the trays with a small amount of water for the pots to soak up. Depending on the size of your collection and the media you choose each of these have their benefits, people who grow in live sphagnum may find misting helps keep the sphagnum lush, people who use akadama might find top watering the best as it keeps the media evenly moist without allowing it to get soggy and break down, and people who use coco husk may find the tray system the best since coco wicks water well but will not get soggy. In my collection I use a mix of these methods, many of my smaller plants are in trays, while larger plants get top watered, and ones with live sphagnum moss will get misted as well to keep the sphagnum healthy. I always recommend that people top water their plants until they get more experienced and can experiment with other methods.

Light

Nepenthes are found in many different ecological niches, from deep dark jungles to exposed mountain tops, but the vast majority can be grown under similar lighting conditions. While problems with lighting only rarely kill a Nepenthes, it can impact the main reason we grow these plants, the pitchers. One of the most common questions I see people ask about their plants is why is it not pitchering, and most of the time it is due to lack of proper lighting. People often forget that our eyes adapt readily to different light intensities, and what might look really bright indoors might be less intense than the darkest shadow

Nepenthes nigra, a species especially sensitive to high light levels

you see outside, and this carries over to lighting for plants. It is challenging to tell by eye whether a light is bright enough to grow Nepenthes, the best way to is copy what other successful growers do and then slowly adjust these methods to your exact situation. In the past most growers used fluorescent lights, however in the last decade these have been replaced by LEDs which are more efficient and last longer, but unlike fluorescents, there is no standard LED so you have to avoid cheap products that may seem bright but do very little for your plants. While it may seem like an expensive investment at first, a 100 dollar grow light can be the difference between seeing only green leaves and seeing beautifully colored pitchers on your plant. Brands are not important, but you need to look for quality lights, avoid clamp and gooseneck style lights, and primarily look for panel lights which are generally better quality. While there is no singular way of figuring out exactly what lights and how many you need for your space, I generally look for quality panels that around 100 watts, I find that these can usually cover a maximum of a 3ft-by-3ft space when placed 18-24 in above the plants. I prefer ones with a warm white spectrum as these are better for photographs however the color of the light should do little to impact growth, what is important is a proper spectrum, you want a panel that uses a variety of LED types to cover a fairly even spectrum of light, focusing on plant available wavelengths (PAR). In the past purple-colored (blurple) lights were popular but these have shown to provide no real benefit over

Nepenthes maryae basal pitcher

Nepenthes lavicola

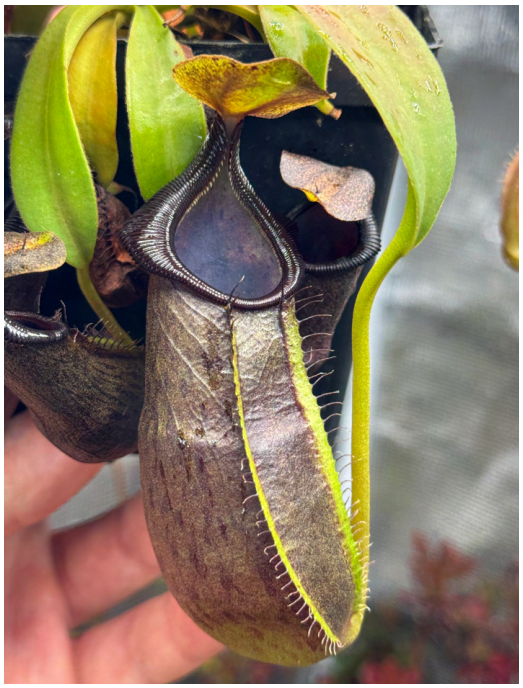
normal white colored lights. Once you chose and set up your lights it is important to keep a close eye out for burning on the leaves if the lights are to close, color changes are normal when acclimating plants to new lights, however if there are any brown or dry spots on the leaves the lights should be raised to be further from the plants, and if the plants new leaves are thin and very dark green the lights should be lowered to be closer. Another aspect of lighting is how long you keep your lights on as this is directly related to how much energy your plants receive, in nature these plants grow very close to the equator and so cycle of 12 hours on and 12 hours off is most similar to what they experience in nature. That said, I have successfully experimented with as little as 8 hours a day or as much as 18 hours a day of light without issue, in these cases you just need to make sure that the light intensity is relative to the exact cycle that you use to make sure your plants receive the right amount of light.

Temperature

Temperature is arguably the most important aspect of cultivation for highland nepenthes as it's what separates these species from the lowland and intermediate species. Highland nepenthes generally require warm days and cool to cold nights, I generally recommend day temperatures in the 70-79f range and night temps in the 54-58f range. While these are guidelines and you can deviate from them to a degree, some people try to get away with too warm temperatures, often with disastrous results. One of the common questions I receive is whether a new grower can get away with growing a challenging species like villosa on their windowsill. When answering this question I try not to discourage the inquirer, but my answer is always an emphatic no. I still frequently see people post photos online showing a newly acquired villosa, or similarly difficult species, with a description of how they are growing it, sometimes with a "new cooling method" they discovered to provide highland temps, and some even scoff at more experienced growers by saying that the plant has lasted them a

Nepenthes diabolica, one of the species most sensitive to high temperatures

whole month without issue even in warm conditions, yet I always wonder what happened to these plants as they are never posted again. In a later section I will break down highland species and highlight those that I find most sensitive and most adaptable, and while I still wouldn't recommend windowsill growing for any of these plants, the species I highlight that are adaptable would be your best candidates. Effective cooling methods do often require equipment that can be expensive and hard to setup, but they are reliable and when done properly, efficient. Many people attempt DIY methods, which can be very effective such as in the case of aquarium coolers, or practically useless like in the case of Peltier systems. Some people also attempt very low-fi methods such as icepacks, which can work for the short term but are very limited in scalability. In a later section I will break down the best cooling methods for each type of grow space.

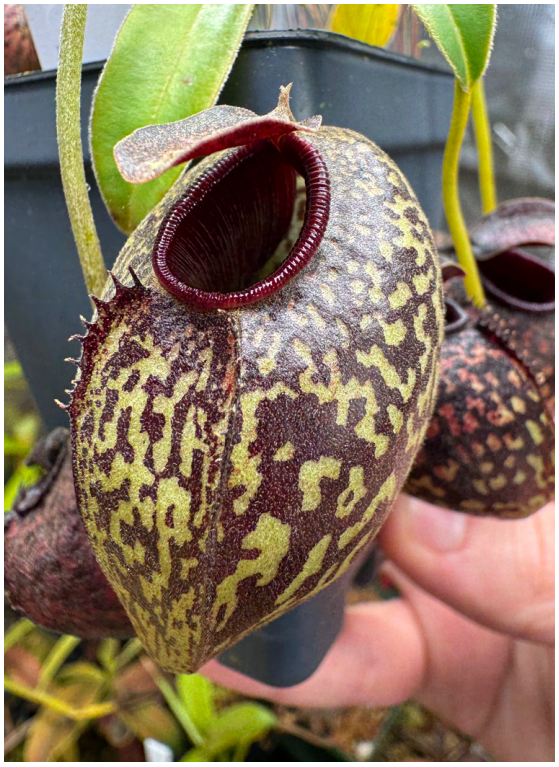


Nepenthes Naga

Humidity

Humidity is one of the conditional requirements that is most flexible, as plants can be adapted to a wide range of humidity levels if other conditions are ideal. Many highlanders come from environments that are known as cloud forests due to their saturated humidity levels, while others come from windswept mountainsides where humidity can drop sharply during the day. Many people advise a fairly moderate humidity level of 80% as ideal as it is fairly easy to acclimate Nepenthes to this level while also being easy to achieve with humidifiers, misters, or even just tightly sealed growing chambers. Along with these high humidity levels airflow is also important, it reduces the likelihood of fungal growth and rot by evaporating pooled water, and it increases plant growth by increasing gas exchange at the plant's stomata allowing for more efficient photosynthesis. But there is a tradeoff, with too much airflow and not enough humidity the plants can transpire too quickly which leads to stomata closing and a sharp decrease in photosynthesis, and in turn, growth. Because of this relationship between airflow and humidity I generally recommend a slightly higher humidity, around 90%, along with very strong airflow. These conditions strike that balance well and also

limit evaporation which means watering needs to be done less frequently. Depending on the size of your collection and the type of grow space you use, there are different options for controlling humidity, for small collections you may just be able to keep them sealed in a grow space trapping sufficient humidity inside. For larger collections ultrasonic mist makers, or commercial humidifiers may be necessary, both of these methods would require a control system to keep the humidity at a set level. In addition to humidifiers some people may also consider misting plants with spray bottles, but while misting can be useful for keeping sphagnum moss healthy, it does not raise the humidity enough nor keep the humidity raised for a long enough period, that it is an effective method of supplying humidity, additionally, misting plants can lead to water buildup in the crown of the plant which can cause rot. High pressure misting systems on the other hand can be a great way to add humidity to larger grow spaces, these systems create smaller water droplets which quickly evaporate raising humidity considerably, they also are generally automated systems, meaning that they come on frequently enough that they can keep the humidity sustained. These systems can still cause water build up in the crown of plants, however, so good airflow and the use of another primary humidification system are important.



Top: Nepenthes aristolochioides, endemic to cloud forests; Bottom: Nepenthes argentii, endemic to windswept ridgelines

Feeding and Fertilizing

Like any other plant Nepenthes need nutrients to survive: nitrogen, phosphorus, and potassium make up the bulk of this requirement, but in the nutrient poor soil medias that nepenthes are found, the only source of these is from insects caught in the pitchers. In the past it was often said that carnivorous plants could not uptake nutrients through their roots, but time and again it has been proven that you can successfully root fertilize these plants, and while it is a technique that can

speed up your plants growth, it can easily be overdone and there is certainly no magic formula to make highland nepenthes quick growing plants.

Nepenthes macrophylla, one of the few species adapted to digesting shrew feces as a source of nutrients.

Nepenthes growers across the globe have experimented for years with different fertilizers and methods, from orchid fertilizers to black coffee and everything in between, and now the collective understanding is that Nepenthes prefer low doses of high nitrogen mixtures. Over many years of use among growers Maxsea brand seaweed fertilizer remains one of the most popular products, and while it is effective, I believe there are better options, because unlike what most people seem to think, Maxsea does contain urea meaning its nitrogen component is not easily accessible in the medias people grow nepenthes in. For this reason, I prefer Osmocote due to its urea-free formula, its ease of use, and slow-release design all of which make it more challenging to over-fertilize and harm your plants. I use a light sprinkling over the soil media, trying to use about 5-10 prills per 4 in^2 area, but one of the best features of osmocote is that it can also be used effectively in the pitchers, 1-3 prills in each pitcher as they age is an extremely effective method of fertilizing your plants without damaging freshly opened pitchers. Fertilizing is still a complicated undertaking, however, and should only be done by experienced growers who can identify the signs of healthy and unhealthy plants and remediate them, it should also be done gradually, starting with one plant at first for a month or two to get the hang of it, then gradually to your entire collection. There are some species such as edwardsiana and diabolica which I recommend never fertilizing due to their extreme sensitivity to nutrients, as fertilizing these species can cause them to stop pitchering and can even damage the plant itself. There are also species such as rajah that can enjoy a higher dose of fertilizer although even with this species you should start with a light dose like I described above first. For beginners in the hobby a great way to start fertilizing is

by feeding the pitchers with live or dead insects such as flies, crickets or ants, these can be an easy and fun way of gaining experience with feeding your plants while also avoiding the risks of overfertilization.

Propagation

Receiving new plants is one of the most fun parts of the hobby, and propagating your plants so you have more can be just as enjoyable. Propagation via cuttings is easy and simple for nepenthes and can be undertaken by anyone who has a mature plant, ones with a long vine as well as at least one basal shoot for it to regrow from. Simply cut the vine into segments with either 1,2, or 3 leaves each and place the cut end into your rooting media which can either be water, sphagnum moss or just whatever media you grow your other plants in. Unlike with many other plants, rooting hormone does nothing for nepenthes and should be avoided as it can dry out the cut end. Cuttings are slow and can take from one month up to a year to start growing roots and leaves again, but you should refrain from touching or removing them in this time, a lot of patience is required and if the cutting will root it will root on its own and if it won't it won't, checking on it frequently will do nothing but slow down this process and may even damage fragile newly formed roots. If you have multiple basal shoots, you can also cut and root these in the same manner as above and they tend to grow quicker that stem cuttings since they already have an active node.

Another method of propagation is via seed, Nepenthes are dioecious meaning there are male and female plants and crossing a male and female plant will produce a hybrid between these two species. Since both a male and female plant are required to produce seed people often ask how they can determine the sex of their plant, but unlike animals the sex of a plant can only be determined when its mature by flowering it, clones and cuttings are all of the same sex so if someone else has flowered the same clone as your plant you can tell that way as well. Some tissue cultured plants do come labelled with the sex as well, if the seller has flowered the clone then that will be accurate however if the sex has been genetically tested in a lab that data should be taken with a grain of salt as errors are common and many of these labels have been disproven over time, one large nursery, Wistuba, has removed

Flowers of a male Nepenthes, unlike most other plants these flowers are quite dull compared to the plant's pitchers.

these sex labels from their plants due to this reason. Once you do have a male and female in flower at the same time (or have procured properly stored pollen), you just need to apply the pollen to the stigma of the female flowers in a very generous fashion, I recommend repeat fertilizations to increase the likelihood of successful seed set. This process is then very slow, you will notice the female flowers swell and then turn brown over several months, and just before the pods look dry and crack, you should harvest them. The seed can then be started on a loose and very moist media such as ground sphagnum or coco coir, they should be started in sealed containers, plastic takeout containers work perfectly, and placed in a bright and warm environment (I recommend intermediate conditions for starting all nepenthes seed). If done properly the seeds will sprout in a few months and in a few years you will have small seedlings a few inches across, starting from seed is a slow but highly rewarding process.

Nepenthes seed starting to sprout on coco media.

Troubleshooting

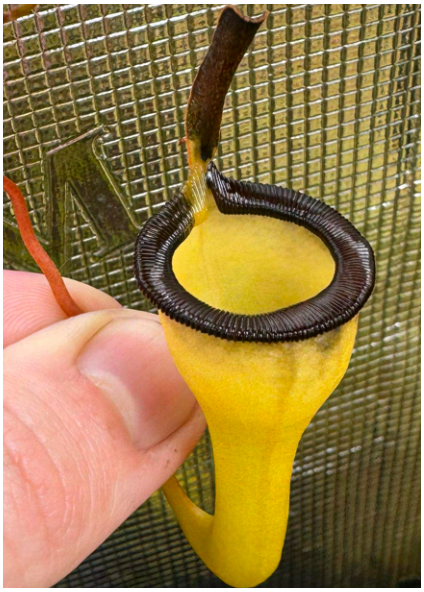
Nepenthes can be challenging plants, especially when you are first starting out, but there are issues that you may face that would stump even the most seasoned grower. Below I will go through some of these problems and methods of solving them and I will also discuss how to identify issues with the health of your plant just by looking at it. One of the most common questions I see regarding the health of a plant is that the pitchers are dying and whether that means the plant is going to die too, luckily while pitchers, or the lack thereof, can indicate whether the conditions are appropriate they do not have any bearing on the health of the plant itself, pitchers frequently die due to a change in conditions and it should be expected that pitchers will die after receiving new plants. Another frequently asked question is why a given plant is not pitchering and in nearly all cases this is due to lack of proper lighting, people generally overestimate how bright their

Nepenthes x pyriformis, the natural hybrid between talangensis and inermis, two species that are notably difficult to grow.

conditions are and so many newer growers do not give their plants nearly enough light, but if lighting is not the issue, checking humidity levels and raising them, if necessary, is a great next step. People also often ask why a plant is turning brown or rotting, and while the previous questions had simple answers this one is a bit more complex. Nepenthes generally turn brown or rot due to one of several reasons, too wet soil media causing root rot, too much water in the crown of the plant causing stem rot, or even too dry conditions causing leaf tissue to desiccate and die. To diagnose these issues, you first need to check whether the soil is soggy or smells acidic, if either is true you need to reduce your watering, then you should check the petioles of the leaves and see if there is standing water and rot forming and if so you need to increase airflow, stop misting, and avoid getting water on the leaves and crown of the plant, if the leaves are dry and crinkly you need to increase watering and humidity levels. Unfortunately many of these issues only become apparent after it is too late to save the plant, but changing your habits based on these issues can prevent further damage, in some cases if there is still living tissue you can cut away the rot and attempt to root the living part just like a cutting, while this may not be successful in all cases it can help save even severely damaged plants. The following is a chart of several other issues you may find with your plants and how to solve them.

Nepenthes tentaculata

Issue(s)	Cause(s)	Solution(s)
Old leaves are turning yellow or brown	As your plant ages old leaves will die off, this is normal	N/A
New growth is becoming smaller and smaller, but there is no evidence of pest damage	Temperatures that are too warm (especially at night) will cause sensitive species to grow significantly smaller leaves	Lower the nighttime temperatures in your grow space, if you are not using any cooling method, read the next section on designing a grow space
Leaves are red or purple, some areas are brown and dry	Light levels are too high, your plant is burning, some species will have darker growth, but most species should be green with only tinges of red.	Raise your lights or lower their intensity if they have a dimmer
Leaves have spots on them, red, brown or black.	These spots are caused by fungal infections, they rarely kill plants but can be unsightly	Apply a product that includes a fungicide such as Bioadvance 3in1
Plant produces new growth but does not form any pitchers	Low light levels are the typical cause of a lack of pitchers, low humidity or over-fertilization may also cause pitcher production to stop	Increase light levels, if light levels are already high, raise your humidity if necessary. If you are fertilizing your plants, reduce or stop.



Nepenthes dubia x jamban, while this pitcher is starting to die, it remains beautiful.

Pests can be another cause of harm to your plants, thrips, mites, scale, and mealybugs are the most common pests for nepenthes but identifying the pest so you can properly treat them can be difficult, luckily there are many chemical agents for treating pests and once you identify the problem treating the issue is easy. Thrips are small insects which are very hard to see, but their damage is obvious, curling leaves and smaller growth is a clear sign of thrip infestations, these pests can be difficult to get rid due to their small size and growth cycles but using multiple weekly applications of a systemic insecticide that uses imidacloprid is an effective method of suppressing an infestation. Mites can be even more difficult to diagnose, there are many types of mites that infest Nepenthes, from the classic spidermite to the microscopic broadmite, if you suspect a mite infestation be sure to look for new growth that appears odd, smaller sized leaves, leaves with crinkled or deformed shapes, and dead spots in leaves can all be signs of mites. Because mites are arachnids rather than insects they need to be treated with a different type of product, systemic miticides such as avid or ivermectin can be used effectively to treat mites, multiple treatments over a few weeks are important to make sure they do not return. Lastly, scale and mealybugs, these two pests are certainly less common on Nepenthes but luckily they are easy to spot, these pests tend to grow on the undersides of leaves and in the petioles. These pests can also be the easiest to treat, using a Q-tip dipped in alcohol you can remove and kill any you find, and treating the affected plants with systemic insecticides such as imidacloprid can solve more advanced infestations. For people with a large collection, I generally recommend a treatment schedule to prevent infestation rather than to just treat issues when they occur. I recommend rotating a few different products to ensure that in addition to killing any pests you also avoid resistance, I use Bioadvance 3in1 in addition to Bonide Fruit Tree and Plant Guard. These products include a mix of insecticides and fungicides and in the case of Bioadvance, a miticide as well. I have not had any outbreaks of insect pests, mites, or major fungal issues while rotating these products and strongly recommend them to anyone who collects Nepenthes. A common question regarding applying these products is whether the products should be diluted for use with Nepenthes, however, because these treatments are safe for your plants and effective they should be used according to their instructions, diluting insecticides, fungicides, and miticides can be dangerous and is never advisable.

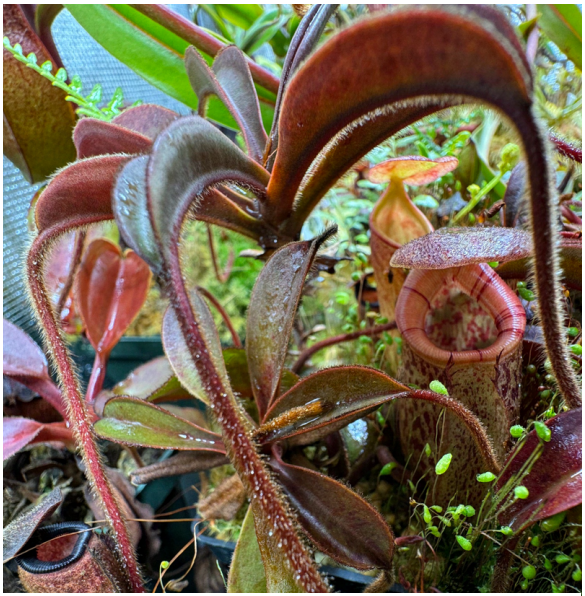
Nepenthes ovata

Creating a Grow space

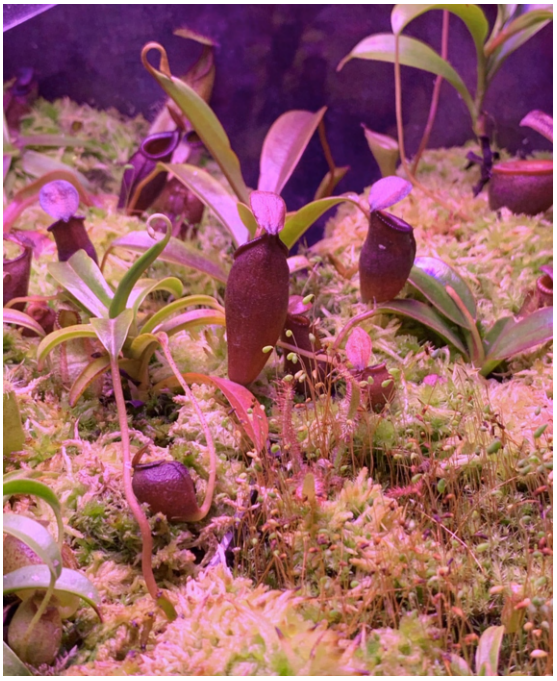
Growing highland nepenthes can be a highly rewarding experience but due to the intricacies of their cultivation it can be challenging and expensive. Luckily there are many simple ways of growing these species that range from a simple afternoon project costing around 100 dollars, up to large intricate systems that may take weeks to build and cost thousands or more. Below I will go through the main types of successful grow spaces for highland Nepenthes and how you can set each one of them up, I will also include a basic list of materials you will need.

Terrariums

Glass terrariums, typically converted from fish tanks, are how almost everyone, myself included, begins in the hobby. Many intermediate nepenthes species can just be placed in a lit terrarium with little other considerations but the temperature requirements of highlanders mean cultivating these can be a bit more involved. I spent many years growing highlanders using solely terrariums, and I learned a lot during this time, much of which I applied to my ever-larger grow spaces and collection. Temperature will always be the most challenging requirement to get right with terrariums, I have tried everything from piping in cool outside air (Living in New England has its benefits) to placing ice cubes near the plants at night; and while these methods all can work, they have their limitations. Piping in cold air is limited by your seasonal temperatures and your ability to keep the temperature in the terrarium in an acceptable range, ice cubes are limited by your ability to replace them every night and by the ice's ability to last all night. After years of growing in terrariums I found the most reliable method to be hanging reusable icepacks from the top of the terrarium (use hooks and attach them to the mesh lid that most fish tanks come with), this method is still limited by your ability to remember to do it every night, but icepacks last longer than ice cubes, are reusable, and don't leave excess water in your terrarium. Other considerations with terrariums are lighting, humidity, and airflow. Lighting is



It's a jungle in there! A few Nepenthes argentii plants with an x alisaputrana pitcher peeking out



A small terrarium I set up for my college dorm.

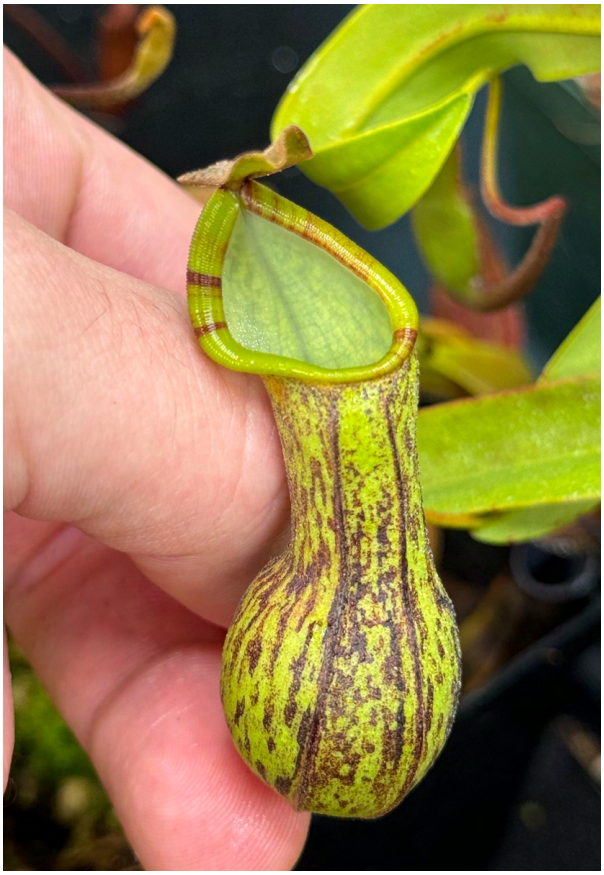
simple and you just need to find lights that are appropriately sized for your terrarium size and have a proper intensity. Because terrariums trap heat, using natural sunlight is not advisable and I recommend using only artificial lights like LEDs to light your terrarium. Humidity is also simple, an easy method is to fill the bottom of the terrarium with an inch of water, then place plastic pots underneath a cut egg crate sheet, to create a false bottom, this will allow sufficient humidity to build up in your terrarium. You should also seal the top of the terrarium so that light can pass through while also trapping humidity, plastic wrap taped onto a mesh terrarium lid works well, as does Plexiglas cut to size. Lastly airflow, small computer fans make a great addition to your terrarium, and they can be placed anywhere that allows them to create even airflow throughout, ones with standard wall plugs are great and can be left on all the time. In small terrariums you can also get by without a fan by either leaving a small opening in the terrarium top, or by keeping the terrarium sealed and just reducing watering and misting. Terrariums are great not just for Nepenthes, but for lush live sphagnum moss which looks beautiful in the pots of your plants, sphagnum moss often grows naturally from the long fiber sphagnum if it is used in potting or can be planted on top of any other growing medium, it provides a great surface for pitchers to form and makes your pots look beautiful.

Components:
Fish tank & lid
Egg Crate & plastic pots
Hooks
Ice packs
LED light panel
Plastic wrap or Plexiglas
Timer for lights

Optional:
Temp probe
Computer fan

Grow Chambers

After some time, your collection will likely grow beyond what a single terrarium can hold, and while you may choose to setup multiple larger terrariums, at some point you will likely decide that you need a larger setup. You may also decide that replacing an icepack every night is just too much work and you need an automated cooling method. Either way the next step in your collecting journey will be a grow chamber, these setups encompass everything from small wine coolers all the way up to large DIY systems with smart controllers, below you will find descriptions of three different grow chambers, how to construct them, and how to decide which fits you needs best.



Nepenthes mikei, this form from northern Aceh is much larger and lighter in color than the typical species.

Wine coolers

Wine coolers tend to be the smallest and most affordable type of grow chambers, and because they are based around a self-contained cooling system, they are very simple to setup. Wine coolers are generally designed to keep internal temperatures around 50-55 degrees which is perfect for highlanders, but you will have to install a timer or day/night temp controller to make sure the system only runs at night and allows the plants to have the warm day temps they require. Another consideration is lighting, ideally the light would hang inside the setup above the plants, and if you can find a light panel that fits inside your cooler that is certainly the best method. But if your panel does not fit, you may have to place it outside, while not ideal, many wine fridges have a glass door which could allow the light to be mounted to the outside and shine in from the side. This does mean plants will grow towards the front of the chamber due to phototropism, but this can be mitigated by turning the plants around at some frequency. Humidity is another concern in these setups, while the chamber is tightly sealed, moisture condenses on the cooling coils in the chamber and can lead to a lot of humidity being stripped out of the air. To fix this issue a water dish can be placed beneath the plants, but this still may allow for large fluctuations in humidity while the compressor is running. Fans can help by increasing airflow and

reducing humidity loss in setups, however most wine coolers have internal fans already so additional fans are often unnecessary.

Wine cooler setups are generally appropriate for small seedlings and slow growing species that will take a long time to reach maturity. Most of these systems have an internal area of around 18x18in and a height of 25-30in, this size cooler can fit about 50 small size (2.5in) pots but limits the height that plants can grow, meaning there can be no quicker growing species whose vines will quickly outgrow the space. Wine cooler setups can be a great way to grow a small collection that you wish to keep in a fully automated grow space, but if you have a large collection or plan to keep buying more plants you may need to use a larger type of grow chamber.

Nepenthes rhombicaulis

Components:
Wine cooler (compressor-based)
Egg crate
LED light panel
Plastic pots
Timer for lights
Timer or Day/Night temp controller
Water dish

Optional:
Computer fan

Chest freezers

Chest freezers are the next big step in grow chambers, they allow for many more plants, and have enough space for plants to grow and mature, but they do require more effort to setup than previous methods. This is the method which I used for many years in my journey through collecting highlanders, it is a great middle ground between small grow spaces like terrariums and wine coolers, and large-

scale setups like greenhouses. Because chest freezers are designed to keep very low internal temperatures (-10 to 0 degrees F) the most important consideration with this type of setup is the temperature control unit. Due to the current required to power a large chest freezer I recommend commercial grade temperature controllers, I also recommend having two units in series because there are many horror stories of temp probes failing or accidentally being removed, and causing an entire collection to freeze. When setting up a chest freezer there are a few other important steps you must take as well, make sure that you remove the door first, it is unnecessary for our purposes and can make it difficult to hang a light, you will also need to build a table of some sort for your plants to sit on in the freezer, a significant amount of water collects in these units and you do not want your plants at the bottom. I recommend placing your plants midway up in the chest freezer so that they have space to grow tall, while also getting enough light and avoiding getting flooded. You will also need to purchase a large sheet of Plexiglas or glass to cover the top, Plexiglas is preferable as it does not shatter and it is easier to cut to size. Lastly you will need to determine how to hang your lights, you can either hang them from the ceiling or build some system to hang them that attaches to the freezer, in my setup I used PVC pipes to raise the light panels above the freezer. Beyond this there are other considerations, because a chest freezer is a sealed system you may think it does not require added humidity, however large powerful units create a lot of condensation, sucking most of the humidity out of the air. For this reason, I used a combination of a misting system, as well as an ultrasonic reptile humidifier with a hose, which were controlled by a timer and a humidity controller, respectively. You can certainly get away with just using a humidifier especially in smaller setups, however a masting system can help keep plants watered for longer periods as well. The next consideration is lighting, because these setups are larger you may need larger LED panels, or you can use multiple ones in series, I prefer to use multiple 100 watt panels as I can arrange them how I like it to maximize even light spread across all plants. I found that my chest freezer setup was very successful

My first chest freezer setup, notice that at this time I was still using fluorescent lights, this setup lasted 5 years before I outgrew it.

and was an effective way to grow medium sized collections, temps and other conditions are very stable in this sort of setup but the biggest limitation is the size of these units. Eventually, before I could upgrade to a larger system I experimented with adding a small cold frame to the top of my chest freezer, I found a model that had the same footprint and used silicone putty to attach the two, this method gave me an additional 15 inches of grow space so I could let my plants vine, while this did mean that there was more air to cool and the compressor ran longer, I found that it was still effective at cooling and was a great way to maximize space.

Components:
Chest freezer
Computer fans
Controller for humidifier
Humidifier
LED panels
Light hanger
Materials for plant shelf (PVC pipe and egg crate recommended)
Plexiglass
Temp controller(s) (Two in series is highly recommended)
Timers

Optional:
Cold frame (to raise height)
Misting system (MistKing brand is recommended)

Nepenthes tentaculata, this Tambusisi form is extremely dark with a mottled peristome.

DIY

Nepenthes ramispina basal pitcher

For those who want a larger setup than a chest freezer can provide, and have the ability to undertake a DIY project, building your own grow space can be very effective. These types of setups can be any size or shape and can use many different cooling methods, however I will simply cover a basic design and the two most effective cooling methods. When building your own DIY grow space one of the first considerations is with building materials, the previous setups I described had little to no construction required however the entire enclosure will need to be build from scratch now. Because your setup will need to withstand high humidity and should be watertight I recommend using either vinyl boards or weather-proofed wood panels for the enclosure itself and treated wood or metal for the structure, either of these methods will keep your enclosure water-tight, however using wood may result in more maintenance in the future. You can also use a plastic liner on top of the wood or vinyl if you want an additional waterproof barrier. You will then need to design and build a frame to which you panels can be attached, your wood or vinyl panels can then be fastened to the frame, leaving a cut out in the front for doors. These doors can be a single sheet of Plexiglas set in groves made of wood or vinyl so that they can slide open or closed, you should make two grooves so they can slightly overlap in the middle, and you should cut a small finger hole to facilitate opening them. You will also need to consider how to hang your lights, you can either use the hanging wire they came with and fasten it to the top or build a bracket to attach them lights to the ceiling. Once you have planed the enclosure of your grow chamber you can then consider how to control temperature, there are two main methods that can be effectively used to cool DIY grow chambers, using an air conditioner or building a radiator cooling system. Window air conditioner units are cheap and easy to setup, but they do require a bit of additional planning, since they must be installed in the wall of your chamber, and must have a support structure build to hold them. These units can easily cool a grow chamber to proper temperatures, however to do so you must override their built-in temp probe, to do this you must remove the front cover and take the analog probe off of the front of the air conditioner's radiator, this must then be attached to something to keep it warm, a Coolbot brand device can be effective for doing this and controller the set

temperature, or a simple fish tank heater can work as well. Radiator based cooling systems can also be effective in DIY grow chambers, they require less planning and simply require two small holes to be cut in the side of the enclosure, however they have more parts and can be expensive to setup. First you will need a liquid radiator and a high-powered computer fan that can be used to blow air across it, the radiator and fans should be hung in the top of the enclosure so the warm air in the top is cooled and can settle down over the plants very evenly. You will then need to consider how to cool the water in the tubing, the most common and easiest way is to use an aquarium chiller, these are expensive but cool water to a cold enough temperature that it can be used to cool your enclosure, remember the water needs to be well below the temp you want the enclosure to reach. Another method is to forgo water and use a liquid that does not freeze, you can then use a small freezer and pump to constantly cycle very cold liquid from the tubing coil placed in the freezer to the radiator and back, this method allows for faster cooling because the liquid is at a lower temperature, however it is very complicated to setup so I recommend a water chiller to most people who want to use the radiator method. The next consideration is humidity, ultrasonic reptile humidifiers with tubing can effectively raise the humidity in DIY grow chambers, and only require a small hole for the tubing to be drilled in the enclosure, misting can also be effective and since misting systems are typically based on 1/4in tubing, installing misting heads is very simple and only requires a single small drill hole. Building DIY setups is clearly much more complicated than the other methods I previously described, I recommend this type of setup to those who have some building experience and those that are willing to spend a lot of time testing and redesigning their setup, and while they can be very effective, for most people looking to expand their collection, one of the next grow spaces may be a better option.

Nepenthes spectabilis with a small lowii upper pitcher in the background

Components:
Treated wood or metal for frame
Waterproofed wood or vinyl boards for enclosure

Computer fan(s)
Egg crate sheets
Humidifier
Humidifier controller
LED panels
Misting system (Mistking brand recommended)
Plastic pots
Plexiglass sheets
Silicone caulk for sealing
Temperature controller
Timers

and
Window AC unit
Or
Water chiller or freezer & pump
Tubing
Radiator
Computer fan(s) for radiator

Nepenthes singalana x diabolica, a fantastic horticultural hybrid between two highland species

Large-Scale Grow Spaces

Once you have built up a very large collection of Nepenthes you will reach a point when any of the previous methods are far too small to house your collection, you will need a larger structure to house and showcase your collection. While they may seem quite different grow tents, grow rooms, and greenhouses all share many features, their structures may differ, however their base components can often be interchangeable. When choosing between these types of grow spaces you will need to consider location first and foremost, you must decide whether you want and can facilitate and outside greenhouse, or whether it is more appropriate do use an indoor setup. Your local weather, seasonal changes, and amount of sunlight can all impact whether or not you can easily setup an outdoor greenhouse, consider how expensive it would be to cool a greenhouse in hot Texas summers, or warm a greenhouse in cold Minnesota winters. Greenhouses also require long sunny days with little shade unless you are willing to supply significant supplemental lighting, picking a spot to place a greenhouse can be the most important aspect when choosing that type of grow space. You also need to consider whether you would have an ideal indoor location for a grow tent or grow room, these grow spaces take up a lot of space, can be messy, and often leak

water, because highland nepenthes require cool temps at night placing these setups in a basement can help make cooling a bit easier and more energy efficient.

Grow Tents

Of the three types of large scale grow spaces, grow tents are by far the easiest to setup, and even the largest of tents can be built in a few hours. While grow tents do have more limitations in size than the previous two grow spaces, there are many different sizes to choose from and large models can house many hundreds of plants. Grow tents are also convenient because their internal frame is strong and can be used to hang lights and other components, additionally their fabric structure while strong, is thin enough that it can easily be cut to allow for additional openings for AC units. The first main consideration after choosing to setup a grow tent is location, tents are large bulky and tend to collect, and in turn leak, water; finding a location in a cool area such as a basement where the tent will not take up too much space and any mess is not important, is key. Once you have chosen a location and set up your tent the next consideration is where in the tent will you grow your plants, some people choose to place plants directly on the floor of the tent, but this can make it difficult to enter the tent, water plants and preform maintenance. I recommend using modular wire shelving, these shelves can fit many plants and can allow you to setup multiple levels, increasing the number of plants you can fit. I personally like to get shelves that are three feet tall with two levels as this allows for seedlings on the lower shelf while mature plants and long vines can fit on the top shelf, some growers may choose taller shelves with 3 or 4 levels as this can fit even more plants, however this only works if your plants are smaller and don't have long vines, this also requires more lights which will make it more challenging to cool your tent. One consideration with grow tents is how to hold the AC unit, because tent walls

Nepenthes sp. Pinapan, a species which may represent an abberant form of rhombicaulis, this specimen was found to possess subterranean pitchers while doing a repot.

are fabric there is nothing to hold the unit up and so either a bracket needs to be constructed or you can use an additional wire shelf outside the tent to hold the unit at the proper height, with only the intake and output sticking into the tent. To properly control the AC unit you will also need to remove the temp probe in the AC unit and heat it above ambient temps to ensure that the AC can reach temps necessary for highland nepenthes, you will need to use a day/night temp controller to make sure that temps stay within an appropriate range. Unlike the previous setups where I recommended small ultrasonic humidifiers, these are not appropriate for use in larger grow spaces, large, motorized humidifiers such as the Hydrofogger are by far the most effective method to humidify large grow spaces, these units can easily be controlled with a humidity controller and can keep humidity at any level, even saturated.

Grow Rooms

A shelf full of seedlings in one of my grow rooms

Grow rooms are another large scale grow space, these are very similar to greenhouses and grow tents in their size and components but are generally designed around a DIY structure and allow for more flexibility in size and design. The most common way to build a grow room is to construct a frame out of wood studs and then installing walls directly onto these studs. For the walls you can use insulated wall panels designed for walk in freezers or you can use plywood, however if you do use plywood you would have to cover the walls in plastic sheeting to ensure that they are waterproof and can keep humidity sealed in. You should leave a cutout in the wall where you can install an AC unit, and construct a bracket to attack the AC unit to the studs you used to construct the grow room walls. Depending on where you have chosen to build your grow room you could simply use a sealed plastic or rubber flooring, if your flooring is cement like in a basement, or you may need to build a raised floor and seal it if your grow room is on floors that could be damaged by water.

Greenhouses

If you decide to go with a greenhouse a good type to research is a 6x8ft hobby greenhouse, these typically have twin-walled insulated glazing and strong aluminum framing, once you have decided on a place to put it you will need to grade the area and place a stable material such as concrete or leveled gravel as a flooring. You will also need to have a waterline and electrical connection installed at this location so it will be best if you choose a location proximal to your main property. Once your greenhouse is fully installed the next consideration will be temperature controls, in most cases small greenhouses can be cooled with a window AC unit that is installed in the wall of the greenhouse. Some people may also find that swamp coolers provide effective cooling instead of AC units, swamp coolers work on the principle of evaporative cooling and thus are only effective in lower humidity environments, but for those who do live in areas where swamp cooling is effective, these units can be much more energy efficient than AC units and can also help keep humidity high as well. In either case depending on your local ambient temperatures you may at times be able to using venting and fans to draw in cooler outside air to help cool your tent, in addition to the temp controller for your main cooling method you should have another controller attached to a fan or vent to cool your greenhouse with outside air when possible.

A high-pressure misting nozzle used for humidification in my grow rooms.

The next consideration is lighting, if you have chosen an appropriate location for your greenhouse, you will only need minimal supplemental light, mostly during winter seasons where days are short. During summers you may also need to reduce lighting as well as intense sunlight can burn your plants and can also warm your greenhouse so quickly that the Ac unit cannot keep up, for this reason 50% shade cloth should be spread over the top of your greenhouse during the warmest and sunniest months of the year. When supplemental lighting is required LED panels are the easiest to install and these panels can be hung from the beams of the greenhouse, making installation simple, and limiting the amount of sunlight they block out. The next consideration is humidity, greenhouses by default have a lot of airflow into and out of them, and in the case of highland nepenthes this can depend a lot on how much AC you have to use during the day and night to keep the temps within range, or whether you can simply use vents and fans to cool the greenhouse when the ambient

temp is low enough. Because humidity is a major concern it is ideal to use two methods, I recommend a misting system in addition to a motorized humidifier, you may need larger, or multiple units, compared to grow tents and grow rooms. For holding your plants you can either get large plastic or metal greenhouse shelves, or you can use modular wire shelves, either will work however one or the other may function better for your needs and size of greenhouse.

Components for large scale grow spaces:
Greenhouse kit, Grow tent, or Building materials for grow room.
Day/Night Temp controller
Humidity controller
Hydrofogger
LED panels (Grow Room and Grow tent, or supplemental lighting for greenhouse)
Misting system (Mistking is recommended)
Timers
Window AC unit
Wire shelves or greenhouse shelves

Nepenthes mollis

Species

The following list is a breakdown of all currently accepted Nepenthes species that I define as highlanders, you may notice that unlike other lists which use solely altitudinal range to identify highlanders, I also take into consideration the conditions in which species are known to grow best in cultivation. For this reason, some species are either added or omitted compared to other lists, I also make note of those species that are: more challenging (◊), especially adaptable to warmer conditions (∴), and that I have personal experience with (•).

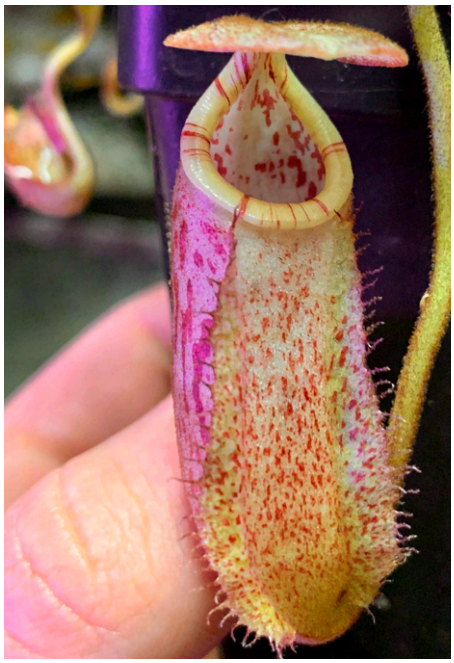
N. adrianii •
N. alba •◊
N. angasanensis •◊
N. appendiculata
N. argentii •◊
N. aristolochioides •◊
N. attenboroughii •
N. berbulu
N. bongso •∴
N. burbidgeae •
N. chaniana •∴
N. densiflora •◊
N. diabolica •◊
N. diatas •
N. dubia •
N. edwardsiana •
N. ephippiata •
N. eymae •∴
N. flava •
N. fractiflexa
N. fusca •∴
N. glabrata •
N. gracillima
N. gymnamphora •∴
N. hamata •
N. harauensis •∴
N. inermis •
N. izumiae •◊
N. jacquelineae •
N. jamban •∴
N. lamii •◊
N. limiana
N. latiffiana
N. lavicola •
N. lingulata •
N. lowii •
N. macfarlanei •
N. macrophylla •◊
N. maryae •◊
N. mikei •
N. mollis •∴
N. monticola •◊
N. muluensis •◊
N. murudensis •◊
N. naga •∴
N. nigra •◊
N. ovata •
N. paniculata
N. pilosa
N. pitopangii •
N. putaiguneung
N. rajah •
N. ramispina •∴
N. rhombicaulis •
N. rigidifolia •
N. sericea •
N. singalana •
N. spathulata •
N. spectabilis •
N. talangensis •
N. taminii •◊
N. tentaculata •∴
N. ulukaliana •
N. undulatifolia •
N. villosa •◊
N. zakriana •∴

Some species typically referred to as highlanders were omitted from the above list because long term experience suggests they are most successfully grown in warmer conditions, these include: barcelonae, boschiana, ceceliae, copelandii, kitanglad, klossii, mantalingajanensis, maxima, nebularem, pulchra, stenophylla, sumagaya, tobaica, and vogelii.

Species Profiles

Below I will profile some of the most popular Nepenthes species, these are species which newer growers often ask questions about growing, as well as those which are some of the most beautiful and remarkable species. I have also given detail about how to grow each species, specific requirements that each species may have, and I have included pictures of each species from plants in my personal collection.

Burbidgeae



Burbidge's pitcher plant, Nepenthes burbidgeae is famous for its large cream to pinkish colored pitchers, which often feature a highly striped peristome. This species is not overly difficult, however it will not pitcher if overly warm conditions are provided, this makes it a good species to grow and access whether your conditions would be appropriate for more demanding species, and it also looks beautiful while doing this role. I also have found that burbidgeae is sensitive to root rot and tends to be a bit more sensitive to fertilizer than some species, I recommend keeping this species a bit dryer and fertilizing it somewhat less frequently than other species.

Edwardsiana

Edwardes' pitcher plant, Nepenthes edwardsiana is one of the most beautiful and most desirable of all Nepenthes due to its famous toothy peristome. Nepenthes edwardsiana has stately pitchers with large razor sharp teeth, it occurs in many colors ranging from yellow to dark red pitchers that almost appear purple. Due to its relative rarity and desirability, it also remains one of the most expensive Nepenthes species, with small seedlings costing around $300, and while edwardsiana is not a very difficult species, due to the rarity and price I recommend that it only be grown by those with experience in highland species as it is always unfortunate when rarer species are killed by those who

lack experience. While Nepenthes edwardsiana is not known to be overly sensitive to conditions, it is very sensitive to fertilizer, and it is very important that you should not fertilize this species unless you are very careful. This species will not only quit producing pitchers, it will also produce small, stressed growth, and it may even die back, when over fertilized.

Hamata

The hooked pitcher plant, Nepenthes hamata gets its name from the teeth or hooks that make up the peristome of this species. Nepenthes hamata is another famous toothy species, it is more affordable and easier to find than the previous species and while it is a bit more sensitive to conditions, it is not extremely difficult. Nepenthes hamata is also very interesting because it varies considerable across its range, some locations have much darker pitchers than others, some have larger teeth than others, and some even have bright red leaves even under normal light levels. Nepenthes hamata is often a species that beginners ask about because it is so unique among the genus, and while it is not very suitable for those who have no experience with highland species, it is easier than some other toothy species like villosa or macrophylla. Nepenthes hamata prefers lower light levels than most Nepenthes species, and it also does best with very humid conditions due to its thin leaves and pitchers. Nepenthes hamata is also very sensitive to mites and will frequently form damaged leaves even when other species nearby are completely unaffected, routinely using a miticide is beneficial for this species.

Inermis

The unarmed pitcher plant, Nepenthes inermis gets its name from the fact that its upper pitchers lack any sort of peristome, and are thus completely unarmed. Nepenthes inermis is an extremely dimorphic species, its lower pitchers are very similar to those of dubia and feature a typical peristome, while its uppers are shaped like a martini glass. Nepenthes inermis is somewhat difficult species, it is

sensitive to rot, low humidity and warm temperatures, and growth points will often die back if conditions aren't ideal. Inermis is a fairly quick growing species once it starts vining, although it is quite slow when in the seedling stage. Nepenthes inermis is also sensitive to fertilizer, while it can be root fertilized without issue, its pitchers are so thin that fertilizer in the pitchers will cause them to die off quickly.

Jamban

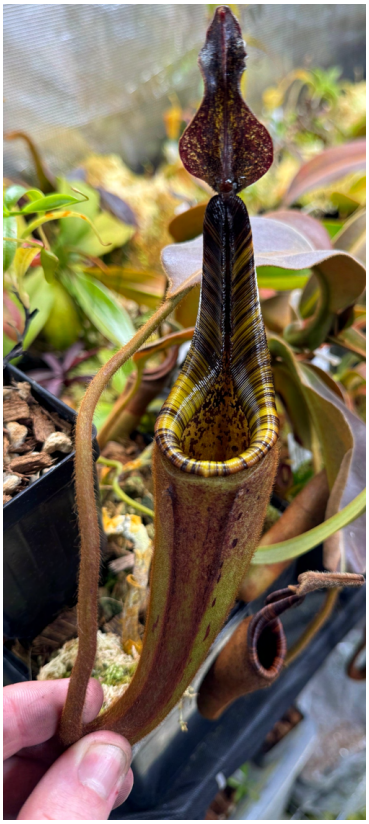
The toilet pitcher plant, Nepenthes jamban is literally named after the indoensian word for toilet, this is due to its upper pitchers which have a bowl that does have many similarities to its namesake. Nepenthes jamban is a beautiful species and happens to be a fairly quick growing and forgiving highland species. While it does prefer highland conditions, it is an appropriate species for people who are newer to growing highlanders because it is more forgiving of imperfect conditions. Nepenthes jamban is a very popular species and does tend to be a bit more expensive than some other similar species, however if you can find rooted cuttings or small clones for sale it may still be fairly affordable.

Lowii

Low's pitcher plant, Nepenthes lowii is famous for its ultra-dimorphic pitchers, its lower pitchers have tall timple pitchers but with large dense lid hairs, while its uppers are squat and toilet shaped with a completely reflexed lid. Nepenthes lowii is also famous because its upper pitchers not only look like a toilet, they produces a laxative exudate and act as a toilet for shrews. Nepenthes lowii is a very unique species and is very desirable among collectors, however it tends to be a very slow grower, to the point that many people nickname this species "slowii". Beyond just being a slow grower lowii tends to be a bit pickier than some species, it tends to be sensitive to wet media and will rot, and it also is sensitive to high temps. While lowii is by no means as difficult as some highland species it is definitely

not a species that should be among the first that new highland growers buy, and should be reserved for those who have gained some experience.

Mollis



The velvet pitcher plant, Nepenthes mollis was named for the Latin term for soft, at the time of its discovery this species was not found with any pitchers and so its name was inspired by int most unique trait that was apparent at the time, the dense mat of hairs that cover the entire plant. The fact that no pitchers were found would also add to a lot of confusion surrounding this species, as many decades later a new population was discovered and was named hurreliana, and it took until an expedition in 2019 to the type population of mollis for researchers to prove that hurreliana was actually the same as mollis. Nepenthes mollis is one of the most unique Nepenthes species in that its pitchers have an extremely tall and elaborate peristome, which is so tall that it sometimes makes up half of the pitcher's total height. Nepenthes mollis is also notable because while it is a slow growing species, it is also fairly tolerant, it is one of the few highland species that actually grows very well in warmer and less humid environments.

Rajah

The king of Nepenthes, which isn't just a nickname, as rajah means king in Malay; Nepenthes rajah is the largest and one of the most beautiful Nepenthes species. Nepenthes rajah is endemic to Kinabalu National Park, specifically the peaks of Kinabalu and Tambuyukon, it grows at typical highland altitudes and in cultivation proves to be a fairly strict highland species. While I wouldn't consider rajah to be one of the most difficult species it tends to be a bit picky in its requirements and plants are often lost when they are not met. Unlike most Nepenthes species, rajah is famous for its extensive root system and large pots are

definitely important when growing this species, my large specimens are each in 1 gallon pots, however I have seen growers who have rajah plants with long vines using pots as large as 20 gallons to ensure that their roots have enough space. Nepenthes rajah is also very sensitive to root disturbances, repotting should only be done when absolutely necessary and even then, the entire root ball, media and all, should be placed into a larger pot with new media, removing any old media from the roots should be avoided. For these reasons I recommend using a mineral based media such as akadama or kanuma, both of which have proved to be successful with rajah. Other requirments of this species, including temperature and humidity are the same as other strict highland species.

Villosa

The villose (hairy) pitcher plant, named such for the dense hairs that cover the entire plant. Nepenthes villosa is one of the most beautiful but also one of the most difficult species of Nepenthes to grow, its extreme sensitivity to temperatures makes it quite challenging to grow without significant experience growing other highland species. Beyond just temperature, villosa is well known for its propensity to rot in wet conditions while also suffering in low humidity conditions as well, villosa is also especially sensitive to changes in conditions. Nepenthes villosa is likely the slowest growing of all Nepenthes species and issues with the plant are hard to detect because while the plant is slow to grow this means it is also slow to die. I recommend growing this species in conditions that reach the low 50's at night, with very high humidity, but with strong airflow as well, to prevent rotting. While villosa is one of the most beautiful Nepenthes species and one that new growers frequently ask about, it should not be grown by those without more than a few years of experience growing other highland species, people often proudly show off villosa that have survived warmer conditions for a few months, but these plants never make it long term. One retailer I spoke to estimated 90% of villosa sold will not survive more than 6 months after purchase due to poor care, while seeing mature pitchers can take as many as 20 years due to this species' slow growth.

Natural Hybrids

Three natural hybrids in my collection, from left to right: N. rajah x lowii, N. ramispina x ulukaliana, N. lowii x tentaculata

While many people in the hobby are species purists who largely prefer natural species over horticultural hybrids (myself included), natural hybrids always remain extremely interesting. Natural hybrids can be large distinct populations that have very stable traits, which are often named hybrids like harryana (edwardsiana x villosa), or they can be random hybrids between any given species that grow in the same area. One thing to note is that in the case of named hybrids the exact cross does not matter, any cross between the two named species is an example of that hybrid, for example edwardsiana x villosa, villosa x edwardsiana, and even back crosses like (villosa x edwardsiana) x villosa are all examples of harryana, this leads to a large variation of traits in any hybrid population which makes collecting them very interesting. In cultivation some natural hybrids are actually more common than the parent species, such as in the case of dubia x jamban being more common than pure dubia, while other natural hybrids such a x Kinabaluensis (villosa x rajah) are incredibly rare in cultivation. This huge difference in rarity stems from how many of each species is in flower at the same time, and the proximity between populations, this can lead to some pockets where there are only the hybrids found and others where only pure species exist, even within a short distance. All in all, I think appreciating natural hybrids is very important, and while some collectors may not enjoy complex horticultural hybrids as much, natural hybrids provide an intriguing juxtaposition between the two.

Undescribed Species

In addition to the species I mentioned above, at any time there are a number of species that are known and may even be in cultivation but remain undescribed, these species may be referred to solely based on where they are found or they may be given an epithet based on physical characteristics, for example there are plants in cultivation known as Sp. Nov. PNG which literally means a new species from Papua New Guinea (these plants are actually from Papua not PNG but the erroneous name stuck), there are also plants like diabolica which, during the time it was in cultivation before its formal description, was referred to as red hairy hamata (due to its similarity with that species). Formal publication of a species is a long and arduous process with many requirements which sometimes means plants are only described many years after they are discovered, this leads to many instances where plants are in cultivation before they are described. Sometimes these species are widely distributed, even by major nurseries such as BE which was very quick to release diabolica (under the name red hairy hamata) only a few years after its discovery, but many times these plants only enter cultivation through seed that is sent amongst experienced collectors by those who discovered the plants.

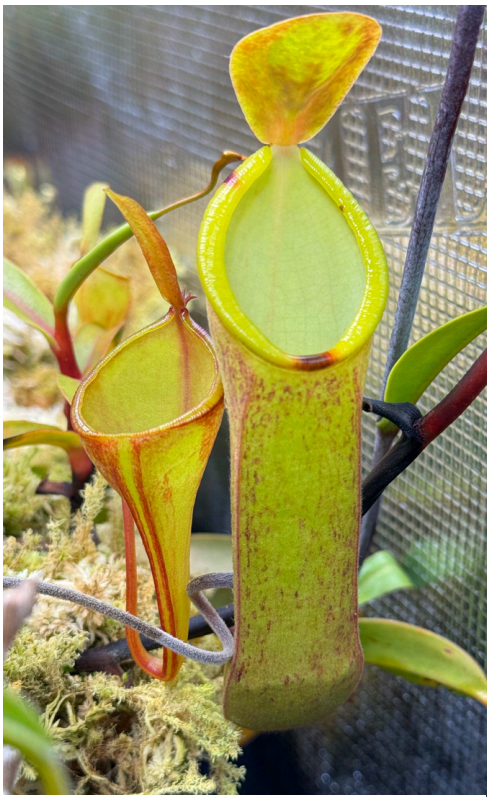
An upper (top) and lower (bottom) pitcher of Nepenthes Spec. Nov PNG, an undescribed species whose epithet refers to the island of Papua, where this species is endemic.

Conservation and Sourcing Rare Species

It is undeniable the impact that global warming has had on the earth's biological diversity, many organisms have rapidly declining populations and many others have gone extinct. But unfortunately, the biggest threat to Nepenthes populations tends to occur at an even quicker pace, habitat loss caused by industry is destroying nepenthes habitat at an unprecedented rate, palm oil plantations cause hundreds of acres to be destroyed overnight and commercial mining activity can literally poison some of the rarest of these plants. These industries tend to be major elements of the local economy and boycotting palm oil for example will likely do nil in the long run. Bringing attention to these plants and supporting conservation efforts at the local and global scale, however, can cause long term impacts, in the Philippines for example, many critical nepenthes habitats have recently been afforded protection by the government. But even laws can only do so much, beyond industry and climate change the next big threat to Nepenthes populations is poaching. Nepenthes are well known for their rarity and high value so the incentive to take plants from the wild to sell is great, especially when considering poverty rates in the areas where many of these plants grow. It does not take very long searching online before you see large cheap plants, often in poor condition, for sale by people in the countries where the plants are native. It is very easy to identify these poached plants and avoiding them is key, these sellers know how valuable these plants are in foreign markets, but if people consciously avoid these sources the incentive to poach will be reduced. And if not just for ethical reasons, consider that people have been arrested, fined, and even federally prosecuted for poaching plants and because most poachers cannot provide documentation required for legal importation, multiple people in the US have been charged with smuggling and Lacey act violations.

Nepenthes maryae, one of the rarest species in cultivation

Sourcing rare Nepenthes species legally can be difficult but it is necessary to avoid poached plants, thankfully tissue culture has allowed many once rare species to become available to everyone, 10 years ago an edwardsiana, for example, was so rare that most collectors could never dream of owning one, but thanks to the increase in tissue culture they are easy to find and much more affordable today. Many species do remain very rare in cultivation and because these are sometimes the most desirable of species you must be very careful to avoid poached plants when attempting to purchase these species. Buying plants from legitimate nurseries that specialize in Nepenthes or carnivorous plants is generally the easiest way to avoid poaching, these nurseries often source plants from large tissue culture labs or grow plants from seed themselves. Many times, it is hard to find the rarest species at nurseries however, but joining dedicated social media groups, and building relationships with skilled collectors can be the most educational and most affordable method of obtaining rare plants. Building relationships with other collectors is key because no one like an out of the blue "DM" asking to buy a cutting of some rare species, and even if the receiver does respond they will often request a very high price. In comparison, if you frequently talk with a collector and show genuine interest in their collection you will likely get favorable treatment. Once you build up a collection of your own, trading plants and cuttings can also be a great way to get rare plants, everyone likes getting things for free and trading is the next best thing, once you have mature plants you can take cuttings from it is often very easy to find someone who will make a trade for something you want. If you do not find any nurseries selling a species and no one wants to trade a cutting, it is often wise to check other sources like Facebook groups dedicated to selling carnivorous plants, and even Ebay; while this hobby is large it is close knit enough that scams and dishonest sellers are extremely uncommon, buyers can rest assured that there is very little risk buying plants from other hobbyists, although it is always wise to stay vigilant.



Nepenthes inermis and Nepenthes murudensis

Another consideration when sourcing rare plants is the seed grown vs. tissue culture (TC) debate, because while TC has enabled many species to become common and affordable, it does reduce genetic diversity in collections so most large-scale collectors and breeders prefer seed grown plants, while TC plants are perfect for most hobbyists. Seed grown plants do have a bit of a dark side as well, nearly all seed grown plants that are pure species or natural hybrids are sprouted from seed that is wild collected. Wild collected seed is distinct from poached plants and given how much seed is produced by a female Nepenthes when it blooms, there is much less harm to a population when seed is taken relative to actual plants, but it does still have some impact and it is illegal in almost all cases. Most collectors still do not seem to realize just how prevalent wild collected seed is in the hobby, and it is important to educate people so they can make their own decisions. While even most large commercial nurseries use wild seed, buying tissue culture plants has far less of an impact as only a small number of seeds need to be taken relative to the enormous number of plants produced through TC multiplication. As more and more new species enter cultivation it is important to make sure that these species are protected, and whenever possible that they are placed in tissue culture to help reduce the incentive for the species to be poached, but it remains the responsibility of the consumer to be mindful of where they are purchasing from.

Nepenthes freshly explanted out of tissue culture onto coco media.

Nepenthes ephippiata