Cactus Cultivation in the Tropics

Eye candy. GBald flowers open in the afternoon and they will close in the evening. One failed flower bud can be seen, near the upper-right flower. June 2014.

The following piece is part of a collection of writings published on the Practical Small Cacti Malaysia site.

A Limited Repertoire

After reading the previous chapters, you should now have a pretty good idea how this practical style of cactus cultivation works. Find species of cacti that work well in a tropical climate. Provide them with adequate nutrition, with emphasis on minerals. Work smart to keep bugs under control.

In the tropics, we cannot easily replicate the incredible pictures of massive commercial operations that you can find on the Internet. Being practical, we try to find things that work, then build on them. It's like painting with a limited repertoire. But these solutions are *well within reach* of any urban gardener in the tropics. These days the bulk of my expenditure is for supplies; I spend very little on new plants and I multiply all those GBalds myself.

In the following, a number of cultivation tasks will be discussed. This material forms a *foundation*; you will also need to read the later chapters for the tons of *little details*.

Nicknames for Scientific Names

PMag = *Parodia magnifica*	GBald = *Gymnocalycium baldianum*
PClav = *Parodia claviceps*	MGeo = *Myrtillocactus geometrizans*

This naming scheme is purely for convenience. Just think of them as webchat nicknames. Other nicknames and additional notes can be found in the appendix to the third chapter.

The Do-Nothing Strategy

The big PMag and the big PClav in an unsheltered location, July 2013. There are three flower buds on the big PClav.

If you have good-sized PMag, PClav or MGeo, you can opt to be lazy and just leave them out in the sun and rain. The two specimens in the above picture have been exposed to the elements for several years at the time the picture was taken. They did flower on occasion, but less than once a year. The soil mix is primarily burnt soil, that fired clay stuff – almost zero organics, for safety.

A do-nothing, leave-them-to-the-elements strategy is a good way of getting large PMags and PClavs to look like natural specimens. The base of the specimens will become very hard, almost woody. These days the specimens that are still left out in the sun and rain are the MGeos. For MGeos, I often use recycled soil from flower pots, supplemented with some scoria, pumice or LECA balls. And they get mineral and fertilizer feedings on occasion.

Three MGeo specimens in the backyard, fully exposed to the sun and rain. Here, they are doing well in what is probably garden soil recycled from a flower pot. The rocks were put there to keep the stems vertical.

This species has a reputation of being indestructible. However, *stressed* specimens can be attacked by bugs. In the past, I've had scale insect attacks on MGeo. *Healthy* specimens on the other hand are very trouble-free. For MGeos in general, problems appear when they get pot-bound. My objective, of course, is to multiply them for use as grafting stock plants. (December 2018)

More eye candy. The impressive thing about fat GBald stems is that they can push out quite a number of flower buds almost at once. This was in December 2014. Note the flower colours – these flowers are not of the same age, but since they often last up to 7 days, you can end up with a pretty impressive display on some days.

Fat and juicy stems are fraught with danger and risks. You've already seen how they can collapse into a pile of gooey mush. So from 2019, instead of force-feeding my GBalds, I did a few new GBald-on-MGeo grafts.

A Work in Progress

My collection is a work in progress. There are many things to try and adjust, so there is no such thing as "the last word" in cactus cultivation methods. Urban gardeners have wide variation in habits, and there are also differences as to how much time, effort and resources each person can expend. Each grower has to adapt ideas and knowledge from here and elsewhere into their own framework.

The pictures – such as the one above – are snapshots of a journey. Keeping GBalds well-fed in their growing phase seemed to me an awesome trick back in 2014. These days I understand better the upsides and the downsides. It is important to *understand* things, then you can decide for yourself whether you want to take risks or stick to safer options.

Where to Put Your Cactus Plants

For most residents of urban Klang Valley, Malaysia, “where to put your cactus plants” simply means making use of what’s available. Gardens are usually small. Or the only space available to you is a balcony. Or a windowsill. These are all limitations that we need to live with.

As long as the location is bright for about half a day and not too shaded, most cacti should do fine. Some direct sunlight is desirable. The South American species that I grow are often lightly shaded by scattered vegetation in their natural habitat, so a full day of direct sun is not necessary.

The next issue is exposure to rain. Large specimens will always do better in an exposed location versus small specimens. You may find smaller specimens struggling out in the open. Is it worthwhile to maintain a struggling collection of small specimens? Would it be worth your time and effort in the long term? A sheltered location is usually a much better choice. I believe rain will tend to wash out minerals in the soil mix and this will hurt the health of your smaller specimens. Minerals can be replaced during waterings or feedings, but this means extra *sustained* effort on your part.

I don’t have a lot of plants, because I don’t want my collection to grow out of control. But enough such that there are cactus flowers every month. You’re probably quite familiar with some of the specimens in this picture by now. These are barely sheltered; they will get wet if it is rainy and windy. Note the flower buds on the big PClav and the PMag flowers about to open. November 2019.

These are slightly better sheltered, by the side of the house. As discussed before, the elevated trays are supposed to be a bug barrier of sorts. These will still get wet if the wind blows in a certain direction during rain. Getting wet is not a problem unless heavy rain results in standing water – then a cleanup should be done. November 2019.

The elevated trays in the above picture is just a temporary setup. A more permanent solution is a multi-level angle iron frame to hold more plants. But a few trays will meet my needs for a long time because I am actively limiting the size of my collection.

I am not interested in greenhouses for an urban tropical setting, mainly because the wind will still blow tiny juvenile bugs everywhere. In other countries, greenhouses are useful for extending the growing season into late autumn or early winter. But in the summer, those same greenhouses have ventilation panels open so that they don't overheat. Tropical greenhouses don't need to extend growing seasons, so presumably they are for protecting plants from bugs and the environment. A sheltered location works well enough for me. I don't think there is a strong case for growing cacti in greenhouses in the tropics, unless a greenhouse is something that is easily affordable to you[1].

Growing cacti indoors near a window works, but it's far from an ideal location. Specimens will often have weak spines. Stems look like they have thinner skins due to insufficient natural light. For example, my batch of GBald offsets grown indoors near a window have very poor spines because the window looks towards the south and do not get any direct sunlight. Thus, indoor specimens are probably a lot less hardy compared to outdoor specimens. Bugs will still succeed in reaching your plants via the window, so regular inspections cannot be neglected. Tiny bugs will even get through mosquito screens. Indoor cultivation can still be useful if we want to exploit etiolation – often cacti that are slightly etiolated grow much faster[2] than those that get full sunlight.

1 And in that case you may need to hire someone to design and site the greenhouse properly.
2 Or you can copy commercial horticulture production and use hormones to boost cacti growth.

The trays in April 2018, about 1½ years before the previous picture. Many of the specimens look to be about the same size; these cacti don't grow very quickly.

As for growing cacti under lights, I had some seedlings growing indoors under one single small fluorescent light; it's strictly limited to small-scale growing of seedlings[3]. But fluorescent table lamps are hard to replace these days, so as of 2021, I grow seedlings near a window. In the future, I plan to use LED lights for starting seeds. Older seedlings grow fine near a window. If you want to grow many small cacti under lights and you want their spines to be nice, you will probably need strong artificial light levels and the monthly cost of electricity may be considerable.

3 It's an ICU (intensive care unit) area for small *Parodia* and HLimi seedlings.

Watering and Feeding

Wet specimens after water spraying in the evening, March 2016. Spraying the fat GBald stem may seem like a crazy thing to do, but I have noticed that practically all GBalds that rot and died are those that were trying to shrink – and doing it badly.

I ‘water’ all my specimens once or twice a week by thoroughly spraying them with water. Clean specimens means no spider mite damage. I do my spraying in the evening, around 5 pm to 6 pm, as long as it was a somewhat hot day. Am I crazy? Am I insane to get the plants wet when the sun is soon going to set? No, on the Internet I’ve seen other cactus growers argue in favour of this practice. But of course, it’s not something that most cactus growers know about or understand.

Here’s my take: For South American cacti whose habitat is in highland or mountainous terrain with climate ranging from subtropical to savanna to desert-like, often *there is moisture* – in the form of *mist* or *clouds* that descend upon the terrain in the evening.

Getting ready to spray some C&S in the evening, March 2021.

Wet C&S due to wind-blown rain, August 2023. Most of my GBalds can be seen in the picture. A lot of rain will tend to wash or leach away minerals. When it rains every day, the plants will get some moisture, but with no new minerals or nutrition. Growth and flower production will suffer a bit, because during extended wet weather, I spray cacti stems less so that they have more time to dry.

The big GStella after being sprayed with water. The skin of the specimen is healthy, and water will dry quickly without any marks. The mineral soil mix is free-draining, always avoiding saturated conditions. This old specimen has a couple of small bleached patches possibly due to heat stress, at the upper left. (Feb 2019)

CAM respiration[4] conveniently dovetails with this cool and misty evening highland weather. When cacti stomata opens at night, the plants can operate in conditions that are much more benign than daytime conditions. The roots of a plant function most efficiently when transpiration is operating normally, that is, stomata need to be open to allow water to evaporate and transpiration pumping to work. Only then can the cactus plant get nutrients via its roots efficiently. Perhaps one can say that many cacti 'feed' in the evening[5] and at night.

I think this is a big reason why C&S do well in the hill resort of Cameron Highlands in Malaysia while they tend to suffer in the hot and humid lowland of urban Klang Valley. If you look for data on the mean annual temperature of Catamarca Province, Argentina (where GBalds come from), it's 16 °C to 18 °C, whereas Cameron Highlands' mean annual temperature is 18 °C. The former is drier but don't forget, mist and clouds engulf the landscape regularly at both locations.

4 We have discussed CAM respiration when talking about the slow growth of cacti.

5 There is also interesting research discussing CAM operation in the evening. Before the sun sets, stomata are open and there is still enough sunlight for photosynthesis, so this time period may be quite important for CAM plants.

Watering them in the morning is not ideal because stomata are closed during daytime, thus transpiration is low and roots are less efficient. However, if your soil mix is free-draining and never stays saturated for too long, then it is a relatively safe thing to do. Sometimes I water large specimens whenever I feel like it, but for small specimens, I *always* stick to evening spraying.

Well, almost. South American cacti are of course also happy to get the occasional rain. When I want to dunk my specimens into a dilute mix of household insecticide to control root mealybugs, I prefer to do it on a weekend rather than rush it in an evening. Spraying cacti with water in the evening is *not an absolute rule*. I haven't come across any scientific paper studying this[6]. However, I think it's a good fit for South American cacti and the reasoning in its favour is sound. For many busy urban growers, an evening maintenance routine ought to be easy to follow.

A GBald with its flowers and stem wet after rain, March 2021. This was one of the specimens repotted in a potting mix of mostly scoria in February 2019 on page 26 in this chapter. GBald flowers often look like this in wet and cool tropical weather.

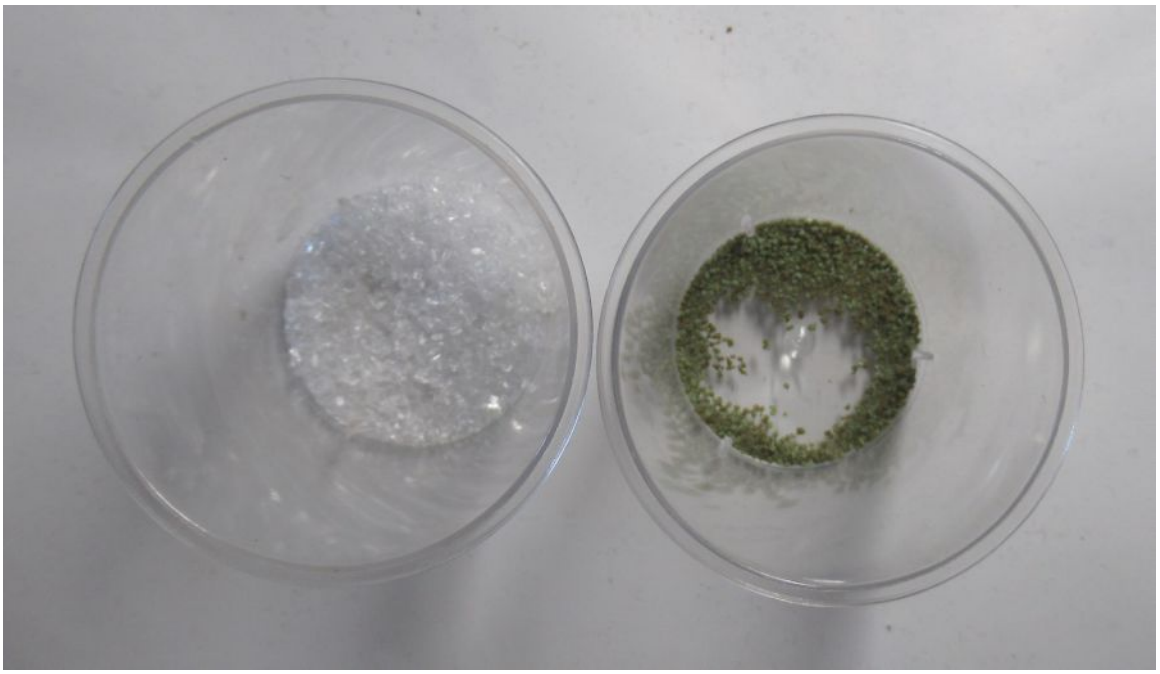
6 Some material can be found online. For example, James Pickering's website has a page on "Cultivating cacti of Eastern Brazil" at `http://jp29.org/brcult.htm`. You might have to use the Internet Archive's Wayback Machine at `https://archive.org/` to read the material.

Spraying Minerals and Nutrients

I nearly always spray my C&S with various mixtures of fortified water. Small specimens always get fortified water. Large specimens are also sprayed thoroughly with fortified water, but to save time I use tap water to get the soil in the pot wet quickly. In addition, large specimens get small amounts of granular fertilizer, usually some organic fertilizer granules[7].

Fortified water is usually a dilute solution of magnesium sulfate and micronutrient microgranules in tap water. The former is always magnesium sulfate heptahydrate ($MgSO_4 \cdot 7H_2O$) because you can easily buy it cheaply in the form of Epsom salt or from online shops selling fertilizer or chemical supplies. As for the latter, I got a repacked bag of a commercial agricultural product from an online shop. If you try to search for such original products online, you will find that many large fertilizer manufacturers have standardized the appearance of this type of fertilizer: it is often dark green in colour and in microgranule form. In 1000 ml of water, I use an amount equivalent to about 2 to 3 rice grains of each component. I once measured some prepared solution at 310 µS/cm. At this concentration I've never had any issues with salt build-up or adverse or toxic effects.

Apart from "mineral fortified water", sometimes the mixture has an added NPK component – after all, plants need NPK too and I don't want my C&S to become malnourished. NPK fertilizers will be discussed in the next section.



Magnesium sulfate (left) and micronutrient microgranules (right). This picture is for illustration only. I use less than the above amounts in a single spraying session. (2020)

7 Organic granules supposedly made from expended coffee grounds. Cleaner and easier to store compared to processed manure. I won't use manure for my cactus plants because I really hate those fungus gnats.

While I can say for sure that magnesium sulfate will make a big difference, I cannot say the same about the micronutrient supplement. For the magnesium you have already seen the progressive improvement of a GSteno specimen. I haven't done any experiments for the micronutrient supplement. The objective is simply to copy the natural habitat of cacti by providing the plants with water laden with some minerals. See this paper:

> Ionescu-Tîrgovişte *et al.*, **The Electrical Conductivity of Various Natural Still Waters**. URL: `https://www.researchgate.net/publication/257141810_The_electrical_conductivity_of_various_natural_still_waters`

The data is from Romania, but one instantly recognizable mineral water brand was measured at 525 µS/cm. The range of electrical conductivity of various types of mineral water is 82–1070 µS/cm. By comparison, tap water in my locality is around 100 µS/cm. In general, there are a lot more minerals in mineral water versus normal tap water. As such, in order to mimic mineral-laden surface waters in a rocky habitat, I will always pick fortified water over tap water.

One thing I did notice when using the micronutrient supplement was the appearance of very healthy-looking algae in a spray bottle, see the picture below. The picture does not do the algae justice, for the colour of the algae patches is really bright green. It's a far cry from the sickly green muck that you can find in drink bottles that are never cleaned. The algae patches convinced me that adding micronutrients and moving from basic magnesium water sprays to more general water sprays of fortified water – a kind of artificial mineral water – is worth doing.

For any other mineral micronutrient needed by the cactus plants, we can supply it via scoria or pumice breaking down in the soil mix. As for pH, I have pH paper strips but I rarely bother with pH testing. Is slight acidity important for cacti? Well, I got 7 flowers simultaneously on a GBald with coral in the soil mix, so I'm not overly concerned about pH *except* with succulents.

Healthy algae in the tube of a spray bottle. (2019)

I haven’t seen any issues with the use of tap water. Some growers think that chlorinated water tends to weaken the lower stems of cacti or turn them woody. I no longer believe that. These days I would point the finger at mineral deficiency. With fortified water, you eliminate mineral deficiency. And for GBalds (and possibly other species of *Gymnocalycium*) the problem is the life cycle of the plant – it needs to shrink the lower stem to pull itself into the ground.

Fortified water keeps woody stems away! (January 2020)

Alternatively, one can argue the case like this: Cacti are slow-growing CAM plants. They cannot feed voraciously because their roots operate efficiently only part of the time, that is, during the night when stomata are open and there is transpiration pumping. But cacti stomata often have water-conservation features; there may be fewer stomata, the stomata may be smaller, or are recessed. So transpiration is weaker versus normal plants. The roots' ability to absorb minerals is weaker too. Thus we should *always* keep cacti supplied with low levels of minerals. Give them plain water and minerals will be washed away via the freely-draining soil mix.

I do have some sodium thiosulfate that I casually use on occasion to dechlorinate tap water, but having checked my picture archive, I don't think chlorinated tap water harms cactus plants at all. Perhaps someone should do some experiments with chlorine. Once you stop a plant from eating its own lower stem by reclaiming the resources there, I think the lower stem will stop turning yellow or woody. My old GSteno specimen (picture on previous page) has a woody base from before it got magnesium supplements. The woody part has not increased in size since 2013.

For indoor seedlings, I use a separate spray bottle with boiled water in an effort to keep everything clean and algae-free. But since I don't use completely closed containers, algae eventually establish themselves in the seedling containers anyway.

Spraying your cacti with fortified water is a simple form of fertigation – the practice of adding fertilizer to the irrigation of plants. More precisely, what we are doing is *foliar feeding*. Normally, foliar feeding means applying a fertilizer solution onto the leaves of a plant. For a cactus plant, we are applying nutrients onto the *stem* instead. This supplements the nutrients that the plant can absorb from the roots. That's not all. Read this open-access paper:

> Ju *et al.,* **A Multi-structural and Multi-functional Integrated Fog Collection System in Cactus,** Nature Communications, Dec 2012.
> URL: `https://www.nature.com/articles/ncomms2253`

In the paper, the researchers studied the glochids (called spines in the paper) of *Opuntia microdasys*. It turns out that glochids, those tiny barbed spines, are really good at collecting fog, which then accumulates as water droplets. The microstructure of the glochid moves the droplets of water to the base where it can be absorbed. Impressive stuff.

We can extend this idea to wooly areoles in general, which are very common among cacti. Healthy plants have a waxy skin and limited stomata, which on the surface appears to hinder water absorption via the stem. But when the mist descends on the mountain terrain in the evening, those wooly areoles will get quite wet. Why are so many cactus areoles wooly? Why does a *Gymnocalycium* or a *Parodia* need to expend resources to produce so much wool on their areoles? The obvious guess: It's an evolved adaptation to collect moisture from the mist or fog.

We can exploit this characteristic of the cactus to provide additional nutrients – just spray them with fortified water and in all probability it will be absorbed at the wooly areoles, right where the nutrients are needed.

Here is the GSteno with a single open flower in July 2019. In the tropics, this species is not quite as happy to flower as GBalds.

Although my old GSteno specimen is quite reluctant to flower[8], observe the younger areoles in the picture above. Can you see how much wool the topmost areoles have? Compare this to GSteno specimens on the Internet – just do an image search for *Gymnocalycium stenopleurum*. The top portion of this specimen is surprisingly *very wooly* compared to other people's specimens. It's a clear physiological response. This specimen may be reacting to regular water sprays – it is producing more wool to collect more moisture.

Practically all *Parodia* and *Gymnocalycium* species in my collection have this behaviour. As such, these cacti may benefit significantly from foliar feeding. At the very least, it's a good way of getting nutrition into the plant. The GSteno specimen has also produced flower buds that were aborted when the buds were still very small. It's quite possible foliar feeding had an effect on the production of flower buds in this case, so experiments on changing the rate and composition of foliar feeding may be worth doing.

8 It has done so only twice. In 2019, only one flower opened.

A closeup of the GSteno in April 2020. The areoles have grown so wooly that many of them look almost like small cups. This may be the result of fortified water sprays. Mountain mist isn't as nutritious. One flower bud (which later failed or aborted) can be seen if you follow the rib going to the lower right corner.

And if you think a bit more, the rate of flowering of my PMag, PClav and GBald specimens may very well have been enhanced by foliar feeding too.

So you see, there are very good reasons to spray your cactus plants.

Some Notes on Fertilizers

After all of that, NPK fertilizing is almost like an anti-climax. Fortified water is augmented with soluble fertilizer powders about once a month. These days I don’t measure the concentration of the solution, but the ballpark or target EC is 500–1000 µS/cm.

The first water-soluble fertilizer that I tried seriously was Valagro Master 15.5.30+2 which includes trace elements, so let’s put it unambiguously as N15:P5:K30:Mg2+TE. It was good at promoting growth, but eventually I came to realize that fat stems with poor spines is poor-quality growth. Next, I switched to something that is more easily sourced: Yates Thrive Flower & Fruit, which I still use occasionally. According to the label, the fertilizer appears to be N14:P2.6:K21:Mg0.5+TE.

Currently I use a couple of powders to add to the usual fortified water. First, potassium nitrate (KNO_3) which is approximately N14:P0:K46 and second, monopotassium phosphate (KH_2PO_4) which is approximately N0:P52:K34. Monopotassium phosphate is also known as MKP. To avoid fat stems, I always use more MKP. Such fertilizer powders can be easily sourced from online sellers. The magnesium and the trace elements are already present in the normal fortified water mixture. This scheme may be more complicated than using Thrive, but I wanted to eliminate urea. This kind of fertilizer mix is *mineral-only* in order to match mineral soil mixes low in organics.

A lot of wool and many buds. Perhaps spraying with fortified water and fertilizer water had a much bigger effect than I expected. (January 2017)

GBalds ain’t fast enough for MGeos. An offset sprouting from the stock. (May 2023)

There are limitations to feeding through spraying though (above picture), remember these are CAM plants with CAM respiration limitations. See the More About Foliar Feeding chapter for the discussion. In general, if you don’t go to the extremes in either direction (too little or too much), I think most C&S are quite tolerant of moderate feeding and will do well.

That’s it. Keep your plants supplied with minerals and they should do pretty well. Some growers however may have a strong preference for natural or organic fertilizers. A mineral soil mix will be necessary. For organic fertilizers, watch out for that nitrogen content!

The Soil Mix

The material in this section was mostly written before 2020, so there is no discussion of long-term outcomes of experiments with soil mixtures. As of 2023, I believe I have made some progress in better understanding GBald behaviour. For the results, you will need to read the later chapters on this website. Even for PMag and PClav, you can also follow some specimens over many years – this may help you to gain some “virtual experience” so that you can better manage your collection of C&S for many, many years.

In *The Stone Eaters*, a major theme is to give space for roots to roam. This means large trays or deep pots for the suggested mineral soil mixtures. Although there is a good argument for this approach, I still stick to plastic pots of traditional sizes. If you want to give your plants every chance to develop their root systems, then you should read *The Stone Eaters*[9].

The problem with large or deep pots, or both, is that it will make my plant inspection rounds harder. A shelf for pots will have to be sturdy enough to hold a lot of weight. Also, I am paranoid about root mealybugs – I won't look forward to repotting or dunking pots when faced with a sea of heavy pots. Lastly, since I focus on PMag, PClav and GBald (everything else is a bonus), they grow well enough that I am not considering a move to deep pots. In my collection, there are no species with deep taproots and no species with special soil requirements... I think[10].

Be advised that when I discuss soil mixtures, it is merely *one approach* to preparing soil for cacti. There are so many different species of cacti and succulents living in varied niches – it's safe to say that there is no such thing as an ideal soil mix for all species of cacti and succulents.

These two MGeos have been taken out of their pots and some old soil have been removed from the root balls. I keep these in rather small plastic pots for a long time, and they do surprisingly well. I am not interested in growing beautiful specimens of MGeo anyway – I just want more stock plants for grafting. (Feb 2018)

9 See the chapter on Nutrition for Your Cacti if you are not already familiar with *The Stone Eaters*.
10 There are a few specimens that are not doing that well; I will need to change the soil mix for those and test more.

Repotting the big PMag. It had just been taken out of the pot. This is the side that faces the wall[11]. The woody lower stem is caused by growing it outdoors in the sun and rain. (April 2017)

The trio of larger species – MGeo, PMag and PClav – are not fussy about soil mixes. The larger PMag and PClav specimens produced many flowers even with pretty regular black soil plus burnt soil[12] plus some LECA balls. When a specimen stops producing flowers and there is no new growth for a long time, then it is pot-bound and you should repot the specimen. If it is not repotted, there will be no flowers and no growth – the plant may be 'stuck' forever.

These days I always give them some scoria or pumice. The bulk of the soil mix is still a black soil and burnt soil mix. Generally, when the root ball is removed, there are no root mealybugs or only traces of them. The roots of these large specimens are probably not the favourite food of root mealybugs. I do not recycle soil from old flower pots for PMags and PClavs, however I do it for MGeos. In the tropics, recycled soil often have all kinds of bugs and some earthworms.

When the proportion of regular soil is high, the *Parodia*s grow an extensive root system and becomes pot-bound in about 2 to 3 years; then they will need to be repotted. With more scoria and pumice, the root system might be different and the plants might be able to stay in their pots longer. As of mid-2020, I am still testing such soil mixes, so the results will be reported in a later edition of this work.

11 I can't provide even sunlight for it unless I regularly rotate the pots. This ain't Huntington Gardens (whose desert garden is probably the most popular desert botanical garden in the US.)

12 A kind of fired clay soil admendment that's cheap and common in Malaysia. It has fines and lumps of various sizes.

The big PClav being repotted, April 2018. The colour of the old soil from the pot is due to a high proportion of slightly moist burnt soil[13]. I decided to repot this specimen after it did nothing much for 4 months – no flowers. The soil that came out of this pot was remarkably bug-free, so perhaps this type of mix is worth trying again.

According to my picture archives, it flowered in 10 of 12 months in 2017, the previous year. The total number of flowers for year 2017 was 30. It did 4 flowers simultaneously in December 2017, and 5 flowers simultaneously in January 2017. Nothing for 4 months didn't seem normal.

13 In this picture, the point-and-shoot camera may have over-emphasized the colour of the soil.

The PClav got a mix of new black soil, coco peat, perlite and I reused some of the old soil. At that time I was running low on scoria and pumice. Flower buds appeared about 2 months after repotting, and in July 2018 there were 5 flowers in total.

Since then, it has continued to grow and produce flowers. From January to May 2020, the numbers were: 7, 7, 6, 11 and 5. So, 36 flowers from one plant in 5 months[14]. Just make sure it has enough nutrition and some water. This specimen flowers all the time and it is much easier to maintain than those GBalds. What's not to like?

A large plant will have a large root system that is quite robust, so it will tolerate a wide range of soil mix types. Since I buy a variety of supplies for experimentation, I do not have permanent formulas for soil mixes. For hard-to-kill cacti like MGeo, PMag and PClav, the main concern is growth stopping due to the root system becoming pot-bound. Generally, dealing with these large specimens is easy, as long as you don't mind the size and weight of the pots and plants.

As for small pots, it's akin to making the best use of an imperfect container. Large pots retain moisture more evenly compared to small pots. In hot weather, small pots will dry quickly near the soil surface and so moisture distribution is less even. The more rapidly changing conditions in small pots may not be ideal for small specimens. Small, slow-growing cacti usually have little reserves. For now, the common plastic pots I use for small specimens work well enough. But if you grow other species of cacti, you may want to investigate the use of deep pots or trays.

14 Since 2020, I have a spreadsheet for this data. There are some behaviours that I want to study in more detail.

These two GBalds had just been taken out of their pots. Some perlite can be seen, but the smaller whitish bits are probably root mealybugs. (March 2017)

GBalds are a whole other ballgame compared to those large *Parodia*s. In the picture above, you can see the typical look of the root systems of older GBald specimens. The soil mix was fairly rich. There are usually some thick anchor roots, while the thin fibrous roots easily crumbles away. It's not much to look at. Deep pots would be wasted on such fragile and weak root systems.

Take note of the lower shrunken stems. Most of the time, the lower stems are hidden in the pots. These parts are not woody but corky and moderately flexible. The roots only grow near the base; no roots grow from the shrunken stem. I have cut open some specimens that were in poor shape and there is slightly moist spongy tissue inside. The healthiest things inside were the vascular bundles – the rest looks to be barely hanging on and thus will unlikely have any capability to produce roots.

While shrinking, a mature stem that is turning from green to yellow often produces a number of offsets. Once it is fully shrunken, it's like a poor version of a tree trunk.

In other words, the root system of a GBald is not very strong and it's connected to the healthier green part of the plant by a weak link. Soil in contact with the weak stem is a risk factor. In my pots of GBalds these days, it is mostly scoria that is in contact with the weak stem. So far I have not seen bugs roaming about in the top layer of scoria. In this way, I hope to maximize their life expectancy.

Three GBald offsets that were rooted at about the same time. By April 2020, each of them has produced at least one flower. (March 2017)

These root systems look different (picture above) because the specimens haven't shrunk their lower stems yet. These three specimens are probably the same ones that were pictured at the end of the chapter on Useful Concepts. They are rooted offsets that haven't stopped growing. Only fibrous roots are visible. One of the three was pictured later with a mild scale insect infestation in October 2019 in the chapter on Battling Bugs. By that time, the lower part of the plant has clearly shrunken. Anchor roots are probably more prominent on older GBald specimens.

The picture indicates that the plants in loose soil mix have better root systems than the plant in black soil. However, the plant in black soil has the largest stem among the three, even with a rubbish root system! It would appear that some small slow-growing cacti do not need a very large root system. But do keep in mind that establishing cactus offsets in black soil is a risky thing to do because of those pesky fungus gnats.

In the next page are a couple of pictures of a GBald repotting session. The burnt soil sandwiched between cheap nappy liner is an experimental barrier to block root mealybugs from below – this has already been covered in the chapter on Battling Bugs. There is a layer of new black soil plus scoria in the middle where most of the roots will be, and finally a top layer of scoria is added.

The idea is to limit the amount of organics in the pot and to discourage bugs from entering from above and below. Fibrous roots will penetrate into the burnt soil layer to get moisture and into scoria to get minerals. Nutrition is mainly through water sprays – I do not expect the plants to live on what is in the black soil. Cacti can often be found nestled in cracks between rocks in their habitat, living on small amounts of organic matter, so my scheme is in no way extreme to these plants.

GBald specimens being repotted in February 2019. No roots can be seen because the roots were removed – I wanted the plants to grow new roots. Burnt soil has been sandwiched between pieces of cheap nappy liner. Some black soil mix has been added to the smaller two pots. Later, a top layer of scoria will be added.

Just after repotting, February 2019.

There is a difference in philosophy when repotting large specimens versus repotting GBalds. MGeo, PMag and PClav all have strong root systems and you can almost treat them like a regular houseplant when it comes to repotting. GBalds however, need a completely different way of thinking.

In their natural habitat, GBalds shrink into the ground during the dry season. The shrinking lower stem and some anchor roots accomplish this. The more common roots – the fibrous roots – can be extensive but they are quite fragile. The root system of a GBald can hardly be called robust, but it is really no problem for these plants in habitat. The fibrous roots that die will just add to organic matter underground, right where the next generation of GBalds will grow. The challenge to the grower is how to best maintain this fragile root system in a 'domesticated' setting.

In the following two pictures, you can see that a lot of fibrous roots have grown since the 4 months after it was repotted. The roots always look too fragile to me, but the specimen is growing strongly and has nice spines. A healthy specimen with good spines means successful care and potentially flowers. If spines are weak but growth is strong, it may mean that the plant is being over-fed.

Four months later, there has been significant new growth with healthy spines. This pot was tipped over when I stepped on the saucer while trying to take pictures. The inside of the pot can be seen in detail in the next picture. (June 2019)

Fibrous roots were holding some of the scoria in place. The roots are kind of like glue – the pot tipped over but the scoria still in the pot was held fast. (June 2019)

So far, I like the performance of specimens in this soil mix. Healthy GBalds grow almost non-stop in the tropics and mature specimens are often willing to flower. Some appear to be growing while at the same time shrinking their lower stem. They appear to be healthy. It's not possible to compare this to the behaviour of specimens in habitat because all the material that I have seen involves researchers going on expeditions. There is nothing that I can find that involves an extended study of GBalds in habitat. Caring for GBald specimens is far from a solved problem.

From January to May 2020, the numbers of flowers for GBalds in total were 16, 28, 26, 35 and 33. That's 138 flowers from 12 different GBalds in 5 months[15]. In those 5 months, there was at least one cactus flower open in 146 out of 152 days. That's 96% of the time, in a tropical climate.

15 Not all flowers were due to GBalds on their own roots. Some were from grafted specimens.

"Look Ma, no soil!" The flower developed normally and opened normally, over 2 weeks after the specimen was taken out of its pot. (November 2017)

A note on nappy liners: Cheap nappy liners made of non-woven fabric is an excellent soil barrier for cacti in plastic pots[16]. They last a long time and I sometimes re-use them[17]. A regular paper separator or barrier will decompose in the same time frame. Try not to use old paper (especially for anything to do with seedlings) – they tend to turn moldy very quickly.

One final item before we finish with soil mixes: It is possible to keep GBalds for many months without any soil or anything at all (see picture above.) A few specimens flowered multiple times in the few months the specimens were out of their pots due to a supposed dormancy. Getting enough nutrition into the plant is a problem, and if the plant keeps flowering, it's going to drain a lot of its reserves. The active specimens had lower stems that turned yellowish after those few months without soil – they have used up a lot of their reserves and that's not a sign of good health.

16 Most plastic pots will degrade these days. The non-woven liners will eventually degrade too. Trash in urban Malaysia mostly end up in landfills, where microorganisms will eventually break them down. The trash going into the oceans is from other sources. If you read the brief on marine plastics from IUCN, the average urban resident who recycles is hardly the worst offender. Anyway, from 2020, there is now a huge amount of non-woven fabric trash due to the you-know-what. Our use of nappy liners will be miniscule by comparison.

17 I often re-use material like scoria or pumice if they look clean, but *only for the same pot* or specimen.

Multiplying Your Cactus Collection

Harvesting offsets from a PClav, January 2019. This plant produced offsets instead of flowers because when it was repotted in April 2018, a few pellets of goat manure was deliberately placed at the bottom of the pot as a test. Nitrogen fertilization often leads to offsets. The powder between the ribs of the cactus is wool shed by areoles.

In order to increase the number of plants in your collection, the easiest method is to multiply or propagate them by harvesting and rooting offsets. For PMag, PClav and GBald, offsets appear under different conditions.

PClavs are reluctant to produce offsets, but they can be easily pushed to do so using excess nitrogen when fertilizing, see the picture above. Instead of flower buds, offsets appear at the top of the plant. Just detach the offsets and rest them for a few days so that the base dries and a callus forms. A callus in botany is something like a scar, and roots will easily appear from the callus. You can also plop them in a soil mix immediately, but you will be taking an unnecessary risk.

Once they root and start growing, they can be treated like any young plant, much like a commodity cactus specimen. The scars on the mother plant will shrink and within a year, they will be hardly visible. The downside: production of offsets by the PClav means no flowers.

In my picture archives, this is PMag 3rd, the third of my current crop of PMags that has flowered. This was its first ever flower bud. (September 2019)

When a PMag matures and becomes all wooly, such as the one in the picture above, it often produces a number of offsets at the base of the specimen. These offsets can be detached easily for propagation purposes. A large detached offset will grow faster than a small one. If you don't remove the offsets, the single PMag stem will turn into a cluster of stems.

We can also cut a PClav or a PMag into two and the bottom portion will sprout new shoots, that is, it will produce offsets. Cutting a specimen in this way is commonly done when we want to improve the appearance of a specimen. For example, a specimen might have a hopelessly bent stem and you want to make it look better. The bottom part can then become an "offset production factory". You are free to feed it with lots of nitrogen fertilizer since your aim is vegetative growth.

After 4 years since being grafted, I suppose this GBald is pretty old. The lower stem of the GBald is trying to shrink, and offsets are appearing at its base. The stock MGeo had been cut lower and braced with rocks to hold it in place. (May 2018)

For GBalds, older specimens tend to produce offsets near the base of the plant where the stem is turning yellow and shrinking. You should harvest some of these offsets in order to increase the number of GBalds in your collection. Given their shrinking habit, some may do it badly and die on you, so you must expect losses. Losses need to be replaced. Multiplying GBalds via offsets is the easiest way of maintaining a viable collection.

Cutting a GBald into two is a *semi-viable* propagation technique. Both parts should survive the operation, and the bottom part will produce offsets. But then the GBald complication kicks in: the bottom part will act like a shrinking stem and it will turn yellow and shrink while producing offsets. Since shrinking is a one-way street, there is no turning back. The stem will produce a few offsets until shrinking is complete (more or less) and *that's the end*. You won't get any more offsets because the stem has finished using up its stored resources. The shrunken stem will still be barely alive for a while, like a dried husk. It's hard to tell.

I focus more on multiplying GBalds to make sure I have enough specimens. As for PMags and PClavs, I don't put in any special effort to multiply them because they are not really at risk of turning into gooey mush[18]. But if you ever need to make more plants, multiplying or propagating them via offsets is a very easy thing to do.

Three of the greener PClavs here (upper row) were from the batch of five that were harvested in January 2019. On a lark, I put them in a disposable bento tray with no drainage. No problem for the PClavs. The piece of glued-on PVC is for manually draining excess water. The medium consist of scoria at the bottom covered by a thin layer of black soil. They are doing fine, but could be growing faster if I had fed them with more fertilizer and water. (December 2019)

18 Also, I am more interested in variety, or genetic variation. Offsets are almost always clones. As such, I would prefer to grow out some of the PMag and PClav seeds that I have harvested. But that's another story.

Channel Your Inner Dr Frankenstein, Experiment!

You should now have a solid foundation on how a practical approach to growing cacti in the tropics can work. There is some more material, but most of the stuff critical to success have been covered.

These ideas did not appear fully formed, but are the result of a lot of experimentation and failures. GBald is a troublesome species, but it had great potential – if the problems could be solved. Along the way there were some successes, plus many interesting observations. A picture archive is a very useful tool as it allows a lot of past cultivation efforts to be studied again and again. A lot of reading was done in order to understand the behaviour of cacti with respect to what was observed. This was how scattered cultivation successes was turned into a viable strategy. How viable is it? Well:

Since February 2016, there was at least one cactus flower open in each month in my collection. From January 2020 to May 2020, there has been two months where one or more cactus flower was open for each day of the month. The specimens that flowered from January to May 2020 are: 4 PMags, 2 PClavs and 12 GBalds. The numbers of all flowers in those 5 months were: 28, 37, 35, 51 and 45. One doesn't need a huge cacti collection to reap some nice rewards.

A bee on a PClav flower, February 2015.

A sequence of four shots of a bee on a PClav flower. Thanks to better data collection, I can tell you that it’s the third day the flower is open, so the yellow colour of the petals has faded somewhat. (January 2020)

The first two pictures better reflect the flower’s real-world colour: the automatic settings of the point-and-shoot digital camera tends to mess up the colours a bit in some situations, for example, when the camera is close to the flower.

A little wet after rain. Two PClav flowers in July 2017. If there was no shelter, rain would probably have destroyed the flowers. This may have been the second day the flowers were open, because the yellow colour of the flowers has faded significantly.

For tropical growers like me who rely on commodity cacti for new plants, I do believe there are other species out there that are worth trying. We need to find out how they perform over say, 5 years with good care and proper nutrition. Who knows, one unassuming plant might turn into solid gold. PMag and PClav are two plain-looking species. To *consumers*, they do not look impressive at all: “Oh, the spines are lame. Yawn.” But look at how mature plants perform! And GBald may have lost its past popularity because customers had a lot of problems with them. Now you know how to get past all those GBald problems. Remember, you are not buying a plastic plant. To reap the rewards, one must aim for long term goals as a *gardener* rather than a consumer.

Five GBalds posed, May 2020. It turns out GBalds are worth growing in the tropics. The key is *knowledge*. You must *understand* the species, *learn* its lifestyle, and *adapt* your cultivation methods to it. As of 2020, I think GBald is an great species to grow.

A group of PMag, PClav and GBald a few months later, October 2020. There are ten cacti posed, of which nine have flowers.

Do experiment! Be a Dr Frankenstein and try things. Take lots of pictures and use them to study the effects of your experiments. You too can find out useful things about cacti, and together we can extend useful knowledge about the cultivation of cacti in the tropics (and elsewhere.) ♦

Version Information

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Colophon

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