Roots of Stalled Growth

Lulled into a crisis – mesmerized by flowers. Growing GBalds in rocks initially produced amazing results, but growth ultimately ground to a halt. (Feb 2021)

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

Introduction

In 2018 and 2019, I potted up many GBalds using potting mixes with lots of scoria – adapting the ideas laid out in *The Stone Eaters* – in the hope that the specimens can be maintained in good health for a long time in a rocky medium.

Most GBalds did well for about 3 to 4 years. The flowering GBalds in the picture above were not posed – they were photographed where they were growing. They were potted up in early April 2018. At 34 months, they produced a total of 12 flowers in February 2021. But from mid-2021, the three plants together only averaged 1 or 2 flowers per month. One suspects that they are pot-bound. So "roots in rocks" does work, up to a point. But that's not the whole story.

Nicknames for Scientific Names

PMag = *Parodia magnifica*
PClav = *Parodia claviceps*
GBald = *Gymnocalycium baldianum*
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.

Stalled and Shrinking GBalds

The GBalds that were potted up in 2018 and 2019 were generally most productive in 2020 and 2021, with a peak in February and March 2021. From late 2021, most specimens slowed down. And by late 2022, many were visibly in decline, like the shrinking specimen in the pictures below.

Now, when faced with plants that have stopped being productive, most cactus growers would come to the conclusion that the specimens are becoming pot-bound and they need to be repotted. It's the reasonable thing for a gardener to do. But I'm a Dr Frankenstein sort of gardener and I do a lot of unorthodox things to my plants. Spraying the stems and foliar feeding should still be getting some nutrition into those plants, but *the GBalds have stopped responding and ground to a halt*.

By August 2022, the total number of GBald flowers per month has dropped to about 10. While that may sound good for a grower of small cacti in the wet and humid tropics, I have been sustaining 30 to 40 GBald flowers for more than a year, buoyed by a few strong grafted GBald specimens.

It was a crisis of sorts. Even the "magic formula" of foliar feeding seems to be failing.

Left: A GBald in bloom 10 months after repotting. (Dec 2019) **Right**: The same specimen in very poor condition 3½ years after repotting. (Aug 2022)

The trio of GBald specimens from the front page in May 2022, just over 4 years after potting up. There is still some growth, but slow; two of them produced one flower each in that month (the buds can just be seen in the picture.) The one at left has some fungi damage (it has not been repotted, the larger pot is to hold it upright.) All three have shrunken lower stems. The one at right has a lot of corking on its stem.

Anyway, most of the GBalds could have been repotted, but I wanted to test their behaviour in pots with a rocky mix even after they have become pot-bound. After all, one does not learn a lot if everything runs super smoothly. I wanted to leave some in those pots until the bitter end. The more off-normal things that happen, the more useful data I get.

So for GBalds on their own roots in pots with a rocky mix, they can be grown for about 3 years before problems occur. Flower production is tied to the growth of new areoles; thus it's an indirect indicator of growth that's easy to track. When the flowers stop, you have a problem.

The customary solution would be to repot the GBalds, but in this chapter we will go beyond such orthodox recipes and attempt to explain their behaviour. Understanding why they act in this manner is much more useful than following recipes.

In addition, these GBalds shrink from time to time, and they also produce a corky layer on occasion. Perhaps bouts of hot weather in urban Klang Valley stresses the plants and promotes such behaviour. Being pot bound may also increase stress, making shrinking and corking more likely. At least, this is how many of my GBalds act. If you are growing them in a milder climate, it's quite possible that you may not see your GBalds shrink and cover themselves in a corky layer as much as I have.

A shrunken and corky GBald in September 2022. Imagine this GBald in its natural habitat, buried in rocky soil with only the topmost green part visible along with the flower. It was potted up in February 2019.

The shrinking and corking doesn't alarm me anymore, though they can be pretty dramatic at times. It's probably just part of the normal behaviour of GBalds. If you look at pictures of GBalds in their natural habitat, they are often almost completely buried. Shrinking would help to pull the stem into the ground, while corking would help to protect the parts of the stem that touches the soil. Of course, from the viewpoint of the average cactus collector such specimens won't win any beauty contests. And cacti that hide underground like GBald are not likely to be very long-lived.

From these specimens, we have learned that the useful lifetime for such pots of GBalds in an urban tropical climate is about 3 years. If we go beyond that, treating the pots as permanent plantings, we found out that GBalds go into decline. The latter cannot be avoided even if we apply reasonably good care. So repot your GBalds every three years to minimize problems – it's a good recipe. A final note: My pots of GBalds had almost no roots at the start – purchased specimens won't meet a 3-year lifetime because their root systems are often already quite extensive.

Two views of some GBald grafts six months apart. The scions were purchased from a plant nursery and grafted in October 2021. In the upper picture (March 2022), the scions have grown quite a bit in the 5 months after grafting. But the lower picture (September 2022) showed that they barely progressed in the 6 months after that. There was a (mostly mild) bout of shrinking and corking in May 2022. The second from right scion is not a pure-bred GBald, and it corked over in spectacular fashion – it first *changed colour* into a darker green, then *softened* like it was about to die of a fungi infection, and finally completedly corked over in a shade of dark brown.

Grafted GBalds Had No Business Stalling

Unfortunately, recipes have limitations. I had many other GBald specimens that stopped growing. Blaming everything on them being pot bound simply didn't work.

The behaviour of my 2021 batch of GBald grafts was particularly puzzling (see the pictures above.) Since my 2019 grafts grew extremely well and started to flower after about a year, I thought it would be a walk in the park this time around. And when the growth of the GBald scions stalled, I gave them some time, thinking that there is a lot of variation among the generic GBalds that were purchased. But with nice rootstocks, there is no good reason for the growth of the scions to stall.

GBalds grafted in 2019 (front row) in decline. Note the shrunken MGeo stocks of 2019D (centre) and 2019E (left of centre). We'll get to that later. (January 2022)

In serious trouble about 3½ years after grafting – note the many black patches. Only 2019C (second from left) is still willing to produce flowers. (Sep 2022)

The five surviving specimens of the batch of 2019 GBald grafts also started to show signs of weakening starting from 2022 (above pictures), and got worse as the year progressed.

By late 2022, it was clear that they were not healthy and some were in real trouble. Growth has all but stopped. Because these specimens have been producing so many flowers for about 1½ years, it was like a train wreck to me. For a while, I wondered whether I will ever be able to keep GBalds healthy for a long time.

Pinning the blame on “pot bound” was deeply unsatisfying. Two of my pot-bound PMags did grow and flower to some degree when foliar feeding was applied more diligently. The PMags *responded* to feeding. But these two batches of grafted GBalds have stopped responding to feeding. They are like the GBalds in pots going into decline, except these grafted GBalds appear to have plenty of resources at hand. The modern grower will go, “WTF??!!!” because things didn’t quite make sense.

In September 2022, I took a stab at trying to better understand such GBald behaviour. It was a very relaxed sort of investigation, not a sit-down-to-work-and-expect-results kind of thing. Instead, I browsed my picture archive looking at the histories of these specimens in the past 4 years or so. Gently absorb thousands of images and let it simmer in the back of your mind for a few days. Let the subconcious mind work on the data as a background process.

The concept of “pot bound” is so ingrained in the minds of gardeners that it is difficult to break free of its bonds. Something was needed to help us escape, to make a *conceptual leap*. One thing popped into my head after a few days: There were differences in how the two batches of GBald grafts were made, but only one of them really mattered.

While all the drama with the GBalds was going on, these PMag and PClav specimens kept going without missing a beat. The two small PClavs were underwhelming in performance, but they can probably be improved by repotting. It’s a “pot bound” issue too, but one that is less serious compared to GBalds. (Sep 2022)

Left: Grafted GBald-on-MGeo specimens, April 2019.
Right: Just grafted: A GBald scion on a MGeo stock, October 2021.

The Key to Understanding Stalled Growth

The source of the scions (own plants versus purchased plants) and the size of the scions were an initial concern. However, at least three of the 2021 scions look like bog-standard GBalds and not some kind of cross-breed, and large scions ought to grow faster than small scions. Arguably, if the problem was due to source or size, there ought to be more variation in terms of behaviour.

The key difference was the condition of the MGeo stocks, or rootstocks. In April 2019, the MGeo stems had been recently cut and then left lying about without roots. In October 2021, I prepared pots of MGeo well in advance, harvesting the stems and then making sure they were already established with roots.

The cause of all the behaviours then, was the roots. And just how did cactus roots cause all of this? What did the April 2019 grafts had that the October 2021 grafts fell short of?

New roots. Fresh, new roots.

It may seem a little strange to be accusing small bits of new roots of having outsized effects on the rest of the cactus plant, at least to regular gardeners, but I have been sensitized to such phenomena because of what I have observed. Two examples:

- In the Flowers and Forcing Flowers Part 2 chapter (page 27), cutting an old GSteno into two caused a large number of flower buds to pop up in the top part, which has no roots at all.
- In the Grafting: 2019 Specimens Part 2 (page 6), there is a single MGeo areole without wool, possibly due to hormonal differences as it is near the cut surface of the graft.

New Roots and Hormonal Signaling

GBald-on-MGeo – without roots – in April 2014.

Here's another data point. My 2014 GBald-on-MGeo graft (picture above) started out with the MGeo as an attached stem. Then the stem was detached and grown in a DWC (deep water culture) bucket. Next it was moved to a regular pot. Then the MGeo stock was cut in half and the specimen replanted. Finally the scion detached and was planted in a pot. There was at least four times where the specimen had to basically regrow all its roots. As such, it had many opportunities to grow new roots. The result? A lot of sustained growth and that one scion has produced over 200 flowers, and counting.

What's so special about new roots? New roots have actively growing root tips. In plants, growing tips are the places where plant hormones are produced. Above ground, GBalds have only one growing tip that matters – the top of the main stem, called the apical meristem in botany. Below ground, GBalds have the tips of new roots. Hormones go from one end to the other end and they act as signals to drive plant behaviour.

Do we really need to go into so much detail in order to understand GBalds? I for one think that we do need such detail. A GBald being pot bound doesn't improve your understanding of GBald behaviour if you merely follow the recipe of repotting the specimen. In the tropical climate of urban Klang Valley, GBalds do not grow in a neat and tidy manner. We must understand the species if we want to solve problems with cultivation when things do not go as planned.

Check out changes in the MGeo stock of one grafted GBald (2019E) on the next page. In my old DWC experiments, I have found that GBalds are not heavy feeders. But somehow a GBald scion can cause its MGeo stock to shrink and almost collapse. Hormonal signaling can be pretty wild.

Watch the MGeo stock ‘deflate’, even though it should be able to handle the GBald scion. From left to right: June 2021, August 2021, October 2021.

From left to right: December 2021, March 2022, July 2022. Extra water and feeding led to a slight rebound in the MGeo stock. But I don’t think it was a nutrition issue.

Looking at the sequence of pictures of GBald graft 2019E, it's almost like there is a "grow fast" signal and a "I'm stressed" signal. One can paint a scenario like this: For about 2½ years, fresh new roots promoted the hormonal signal "grow fast". By late 2021, increasing pot-bound conditions led to a lack of new roots, while older roots were starting to strangle themselves. No more "grow fast". The root system is now screaming "I'm stressed". So the specimen changed from strong growth to displaying the characteristics of a stressed plant.

Without the appropriate hormone signal, effort in feeding the specimen will largely go to waste. Being a species of cacti, GBalds need to lie dormant in their natural habitat, largely underground, for months at a time during the dry season. That means "switching off", stopping growth. Who does the signaling? Stem growth is always at the growing point at the top of the GBald. The top of the GBald is connected to the root tips. And it appears that new root tips provide the "grow fast" signal.

There were still some flowers, but fewer, since growth was slowing. In fact, after the single flower seen in the July 2022 picture, growth came to a complete halt. To restart growth, 2019E was repotted in early November 2022. Repotting is a good way to make them grow new roots. With a better understanding of what we are doing, we have a target objective: To get the apical meristem of the GBald scion to receive a good "grow fast" signal again.

Armed with new knowledge, repotting a GBald now includes removing much of the old root system. Let the plant grow new roots. By accident, such a treatment worked really well for a young PClav (picture below). So hack away! As for the 2021 batch of GBald grafts, I believe they didn't get much of a "grow fast" signal. Repotting and results will be covered shortly.

Another clue. This young PClav was purchased in September 2018. When it was last repotted, shown here in September 2020, I had liberally removed a lot of roots.

Here is the purchased PClav with 3 flowers in October 2022, the 4th time it has flowered in the space of one year. The flower totals were: 1, 1, 1 and 3.

Some Musings About Those Hormones

The “grow fast” / “I’m stressed” scenario is just a mental model. The signals may or may not correspond to actual plant hormones. A “I’m stressed” signal could be caused by the lack of a type of hormone or low levels of it. The “grow fast” signal, on the other hand, is easier to explain using current scientific knowledge. I’ll leave proper research work to scientists. In the following, I will just casually go over some plant hormones that are relevant to our discussion.

Rooting powders (or gels) that one applies when propagating cuttings contains a synthetic auxin. Auxins are plant hormones that go from the apical meristem down to the roots, stimulating root development. So if you don’t want to repot a GBald, applying rooting powder may help: signal the roots to grow so that new roots can in turn signal the top of the stem. But it’s not a perfect solution. If the roots are tightly stuck in a ball, you still won’t get healthy root growth.

Going in the other direction, root tips (as in, new root tips) send cytokinins upwards to the apical meristem. Cytokinins promote cell division and shoot growth. This is the type of hormone needed to tell the tip of the GBald to “grow fast”. Synthetic cytokinins are widely used in the horticultural industry to promote growth and so on. The mass-produced plants that you buy in plant nurseries may have been juiced with a variety of hormones so that they look perfect[1].

1 For example, search the Internet for ‘CytoFlor’.

You can probably buy synthetic cytokinins to make your cacti grow faster too. As for me, I have no plans to use hormones. Understanding why GBald growth stalled allows us to better maintain their health. I can already make some grafted GBalds grow continuously and produce about 40 flowers a year; that's peak performance to me and I don't want to juice them up further. I just want to continue to do things without high-tech hormones and chemicals.

I've got no idea about the "I'm stressed" signal and I'm not going to guess. But I can tell you that I have casually tested one GBald for ethylene sensitivity in 2019. Ethylene is a gas that is a stress-related plant hormone. I did the test because an ethylene-producing chemical (such as ethephon) is used to force pineapples – a CAM succulent plant – to flower in commercial plantations.

The GBald that was tested was one of the three GBalds pictured on the first page. It was put in a plastic container along with some banana skin for one night (see the picture below.) And absolutely nothing happened. After the 'gassing', in the following months there was no difference in behaviour between the ethylene-gassed GBald and the other two GBalds that I always keep together as a trio. In the past when there was haze in Klang Valley due to smoke from Indonesian forest fires (a source of ethylene), I didn't notice any effect either.

One unknown in all of this is the effects of dormancy or resting on hormonal signaling. I don't know if continuous growth without resting is bad for GBalds. And I don't know if resting is beneficial to GBalds. For now, I aim to focus on the "grow fast" hormone signal in order to keep my GBald specimens in good health.

A GBald in a container with banana peel, late March 2019.
The GBald was 'gassed' for about 15 hours (about 5 pm – 8 am).

Reviving Some GBalds

Looking at the root balls, it's no surprise that the growth of the 2021 GBald grafts stalled. The scions weren't getting a "grow fast" signal. (September 2022)

In gardening, the best ideas are those that work and have a real effect on your plants. From around mid-September 2022, I started to do some experiments on my GBalds. If the idea of GBald growth controlled by hormonal signaling due to new roots is sound, then I should be able to revive all but the most heavily-damaged GBalds.

The most sensible approach to reviving the GBalds would be to repot them. The repotting technique has to be adjusted. To promote the growth of new roots, a root system is 'refreshed'. Old fibrous and thin roots can be completely removed. Most of the roots that are left would be thick roots – the roots that don't fall off when you rest cacti with their roots bare. The specimens are then left to rest bare-rooted for a few days so that the roots can heal. This means that in the course of refreshing the root system, *damage is inflicted*. Damaged areas will callus over. This is important as callus tissue consists of actively-growing cells – exactly what we need to grow new roots.

For GBalds, I now think that protecting the root ball when you repot is the wrong thing to do. Look at the root systems of the MGeo stocks in the picture above. In the past, I would say that those root systems are still functional, even though it's starting to get cramped in the pots. But not anymore. The roots may still be able to absorb water and minerals, but there are little or no new roots. No new roots means there isn't any hormone signal to tell the top of the GBald scion to grow. Remember, it's an outsized effect: Nothing fresh means no growth.

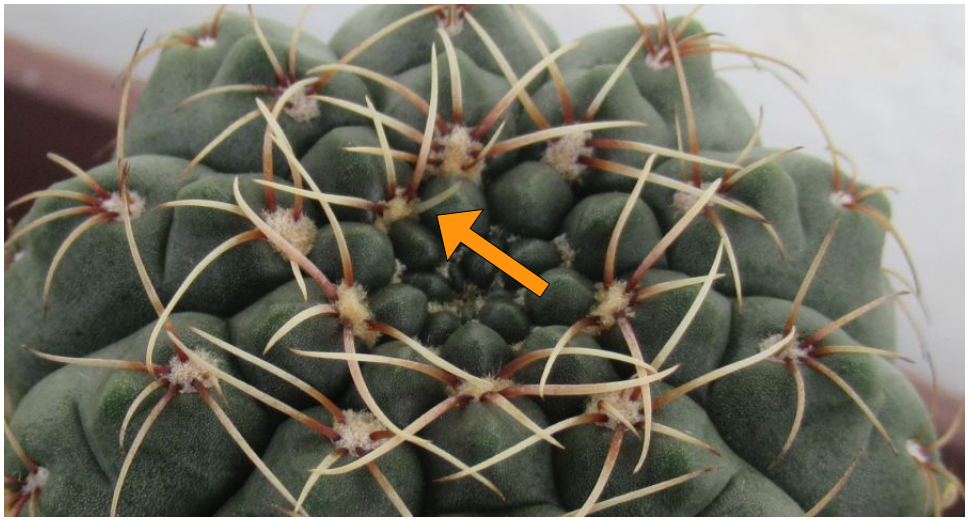
In summary: (A) Hack at the root system, then let it regrow. (B) A strong root system looks nice, but it's still pretty useless if it does not have any new roots to produce the hormonal signal needed to get the top of the cactus to grow.

Three of the 2021 batch of grafted GBalds, after cleaning. Not a lot of the root systems are left. Let the MGeo stocks regrow everything. (Nov 2022)

Potting up after 3 days of resting. The planter box will provide the root systems with more room to roam. Most of the potting mix is new generic potting mix – MGeo root systems will survive in almost anything so I was not picky about it. (Nov 2022)

In the process of repotting three of the 2021 grafted GBalds (2021A, 2021B and 2021C, or 2021ABC for short), the concept of “roots in rocks” has become less attractive. “New roots” takes precedence over “roots in rocks”. Since MGeo root systems are very strong, I simply used a generic potting mix for these three grafted GBalds. A rocky potting mix that is less attractive to bugs is still useful for GBalds grown on their own roots.

After just over 2 weeks, a new spine was seen on 2021B, and after about 2 months, all three GBalds were now growing strongly (pictures below and on the next page.)



A new spine (arrow) on grafted GBald 2021B (October 2022). Growth, finally.

Two views of grafted GBald 2021A. **Left**: Just after potting up (2022-09-19). **Right**: Nearly 2 months later (2022-11-13). The GBald scion is larger, with a lot of new spines growing from newer areoles. Note the lighter areas between the ribs, which looks somewhat stretched. The colour of the scion may also have improved.

Two views of grafted GBald 2021B. **Left**: Just after potting up (2022-09-19). **Right**: Nearly 2 months later (2022-11-13). 2021B has grown a lot, has better colour, and it also looks stretched between the ribs. Of the three, 2021B is closest to the look of the 2019 grafted GBalds when they were growing strongly.

Two views of grafted GBald 2021C. **Left**: Just after potting up (2022-09-19). **Right**: Nearly 2 months later (2022-11-13). The locations of the scars (or corky bits) shows just now much 2021C has grown in a few weeks. New spines growing near the top of the scion is strong and healthy.

Other experiments or ‘revivals’ will be covered in the following sections, along with some other interesting observations. While all of this is not at the level of scientific proof, I like what I see when I look at the many GBalds that were successfully revived. It’s not all plain sailing, however.

A Failed GBald Graft and Unanswered Questions

GBald graft 2021F failed. Here it is being detached in January 2022.

This GBald (I identify it as 2021F in my records) is an interesting case. It was one of six plants in a pot purchased and used for grafting in October 2021. Five grafts were successful, but 2021F failed, and it was shrinking when finally pulled off the MGeo stock and potted up in January 2022. The GBald recovered quickly and growth was strong. As you can see in the second picture below, it looked very nice in April 2022. What a confidence builder! And then everything went south.

2021F recovered and grew fabulously in the next 3 months. At left is the GBald just after potting up (Jan 2022), while at right is the plant after 3 months (April 2022).

Whoops. Six months later, 2021F has crashed again. (October 2022)

Inexplicably, 2021F reversed course and started to shrink again. The potting mix was a fairly loose generic potting soil, and it had no visible bug issues. By October 2022, it looked worse than it did when first potted up in January 2022. And so the GBald was removed from its pot to be revived. The root system (picures below) looked fine, not pot bound. The potting mix did not look like it had been baked in a heat wave – the fibrous roots looked alive. Yet 2021F shrank and shrank.

Removing 2021F from its pot, October 2022.
Left: Doesn't look pot-bound to me. **Right**: The GBald after cleaning.

2021F resting, four days later, just before potting up. (October 2022)

Left: 2021F with some new spines at 11 days after potting up. If it can recover so quickly, just what was really wrong with it? (Oct 2022) **Right**: 2021F looking nice and fat with strong growth exactly 1 month after potting up. (Nov 2022)

Eleven days after refreshing the root system, 2021F has grown some new spines and it was well on its way to ‘unshrinking’ itself. In November, a month after potting up, 2021F has grown a lot, and it was as round and as healthy as can be. Revived. Well, I guess it couldn’t have been a root system viral or bacterial problem. Just what was that root system doing?

While the GBald has been revived and is growing nicely, there are a lot of unanswered questions. The plant grew strongly, then shrank strongly – all in the space of about 9 months. And grew strongly again (after repotting) within 2 months after that. Inflate. Deflate. Inflate. It just doesn't feel like a water or nutrition problem to me. Or a microclimate problem.

Did the root system stop functioning? Was the GBald very sensitive to soil conditions? Was the slightly moist potting mix non-conducive to producing bits of new roots? Or was this GBald very sensitive to stress signals? Is this mass-produced GBald a cross-breed with another *Gymnocalycium* species? I'd like to blame that root system for something, since it likely controls topside stem behaviour, but I've got no idea what really happened.

Were there external signals? Signaling by other cacti is certainly possible and indeed, I've seen bare-rooted GStellas shrinking for no good reason[2]. If you compare the original root systems of these GBalds just after purchase (see the pictures below) and the root system of 2021F in October 2022, they aren't all that different – which is why I don't want to rule out external signals or influences.

So, something went wrong with 2021F and I got its root system, er, rebooted. Then it worked fine again. For now anyway. Part of me believes that the problem is partially solved: by refreshing the root system of the specimen more frequently. It also occurred to me that if a strong stress signal was produced by the many older roots of 2021F, then it's better to *hack them all off*. I know what I'll do when it starts to shrink again... Chop chop chop.

It would be a hoot if the key to keeping temperamental Gymnos (*Gymnocalycium*s) happy is to hack away their roots regularly. I need to gather more data and look for interesting stuff in the data.

The GBalds used for grafting in 2021, just after they were purchased (October 2021). The six had survived fairly well for at least 6 months at the local plant nursery, sheltered under translucent plastic. (It was part of the annual Chinese New Year stock in February.) The original root ball (left) has a loose commercial potting mix.

2 See the Complications of Shrinking chapter.

Experimenting With No Repotting

Remember this specimen from earlier? Here are three pictures of the GBald progressively going into decline. Even while fading, the GBald continued to produce flowers for a while. **Left**: With one flower in late June 2021. The specimen is just past its peak condition; there is some shrinking. **Middle**: With one flower in mid September 2021, just over 2½ years after repotting. The unhealthy colours of the offset is now clearly evident. **Right**: With two flowers in late December 2021. The entire specimen now clearly looks very unhealthy.

Closeups of the offsets as the GBald's decline progressed. **Left**: The specimen in late March 2022. The last flower produced was in mid-April 2022. **Right**: Dry and soft, "skin and air" offsets that look nearly dead, late August 2022.

Left: The GBald at the beginning of the experiment (October 2022). Note the water in the tray and the wet offsets. **Right**: After about one month of ‘treatment’. A bit of green colour has crept back into the stem. (November 2022)

Not every GBald got the repotting treatment. It’s useful to conduct other kinds of experiments to get a variety of observations. In this experiment, we avoid repotting the plants. Two of the worst-looking GBalds were placed in a tray with a small amount of water so that the pots were always very moist. The water in the tray usually dries out in a day or two in normal weather; then water is added again. The objective is to encourage the growth of new roots inside the pot.

One of the GBalds in the experiment is shown above. (The other GBald in the experiment is the crested specimen.) After about a month of treatment, the GBald is slowly recovering from the kind of shrinking that I would normally regard as fatal. Even the GBald’s offsets have recovered a bit. Before treatment, those offsets felt like skin and mostly air – dead offsets. Or so I thought.

This experiment will be covered further in the next chapter. Just how much recovery can be attained by such a heavily-damaged GBald? Something made this recovery happen; that something may well be the hormonal signaling of new roots.

A GBald Tray Stalled and Slowly Stressed

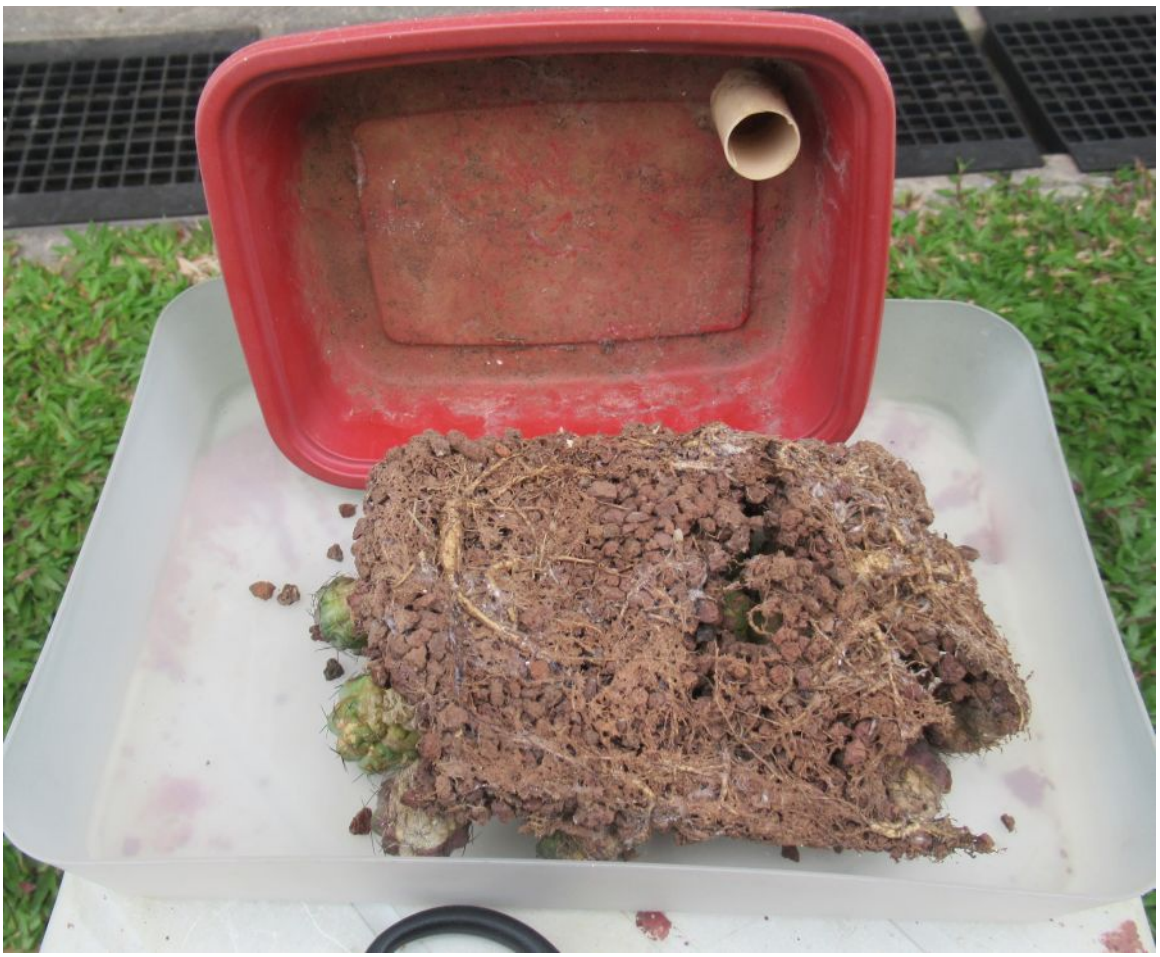
The upper picture shows a tray full of rooted GBald offsets at 26 months (May 2021). The lower picture shows the same tray at 42 months (September 2022). The empty areas are due to six GBalds taken out for planting in August 2020.

These GBald offsets were planted in a tray of scoria with no drainage in March 2019. They looked green and healthy for about 3 years after they were planted. I thought it was a good way of keeping many small GBalds around. But around mid-2022, they started deteriorating.

I did not take many pictures because they looked safe and secure in the tray, unchanged for months. 2022 was a La Niña year in Malaysia and in Klang Valley often there was some rain every day for weeks on end. Extended cool and moist weather is not going to harm these GBalds, right? Probably not, but maybe something else was at work to make them go into decline. Luckily I did take some pictures on occasion, enough for me to casually study this kind of slow-moving behaviour.

From mid-2022, a little more attention to spraying and feeding did not help. The tray of small GBalds kept declining slowly. That's a lot of "3 good years and then decline." Hmmm.

All the GBalds were removed from the tray in early October 2022 (picture below and on the next page.) The root systems were on the dry side, but the thicker roots were probably still viable. Parts of the root systems should still be able to absorb water and minerals though. What's missing are the bits of new and fresh roots.



Out of the tray. The underside of the scoria "root ball", early October 2022. There was a bit of mealybugs infestation. It's unclear whether the bugs had a significant effect, because I've repotted many GBalds and grafted GBalds to be revived in the same timeframe that had zero mealybugs in the potting mix.

Closeup of a few GBalds after separation and a bit of cleaning. (October 2022)

Just before potting up, after 3 days' rest. I didn't want any of the dried-up roots, so everything except the most fleshy bits was removed. (October 2022)

Potting up the small GBalds in two disposable bento containers. As usual, there are no drainage holes, but there is a thin layer of scoria at the bottom. (October 2022)

After potting up. You can compare this picture to the pictures on the next page to see how they fared. (October 2022)

The two trays of small GBalds, 36 days after potting up. (November 2022)

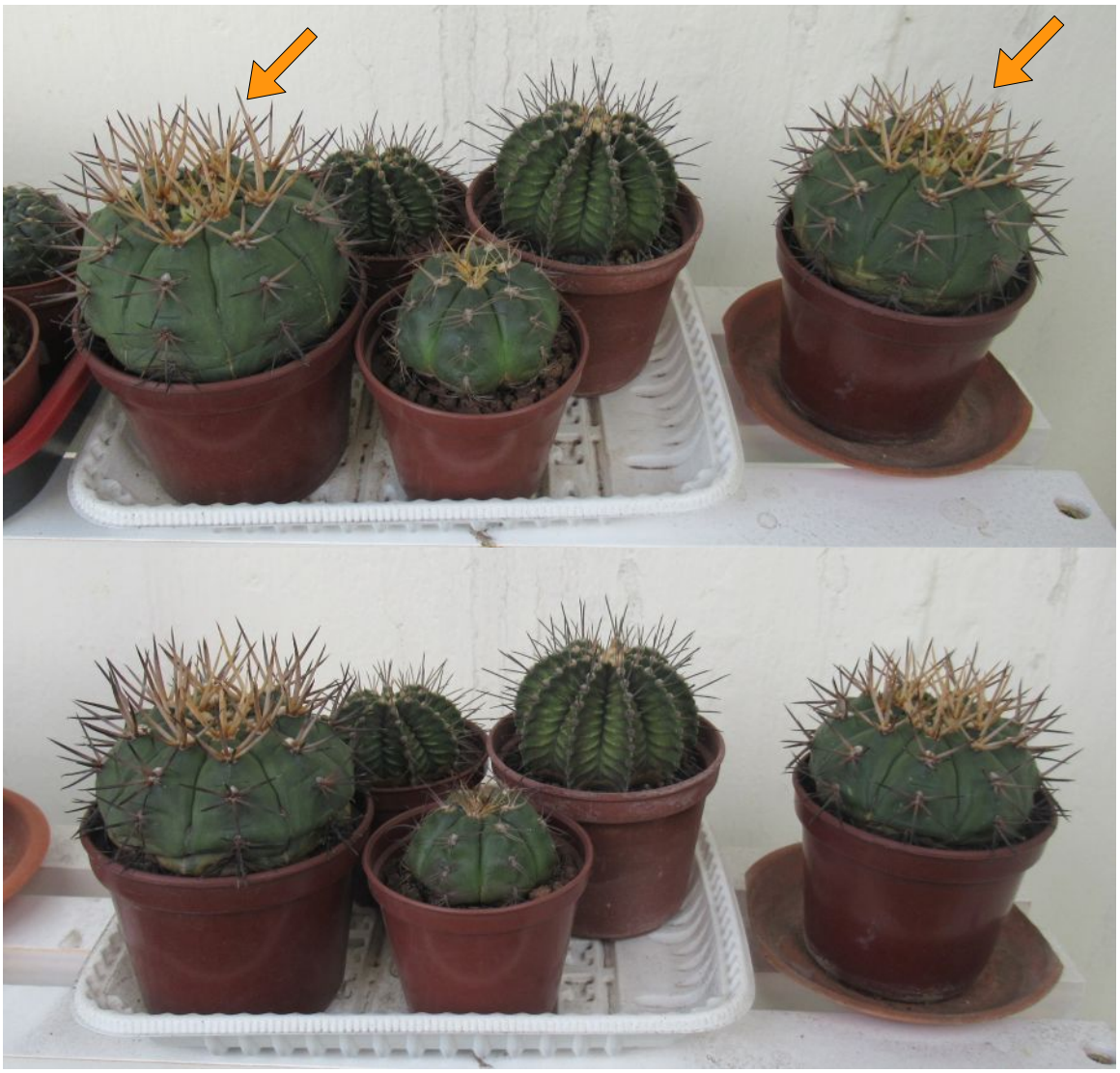
Overall, it's another successful operation. Most rebounded really well, but several GBalds appear to be doing significantly worse. That's another mystery to be solved someday. One unknown is the rich soil, which is clean soil recycled from a pot of bunching onions ('Ishikura'). When fresh, the soil had a pungent onion-like smell. After storage, the recycled soil had a kerosene-like odour (really).

Pots, Trays and Strangled Roots

Subjectively, I think the tray of small GBalds held up well and they declined rather slowly. GBalds in pots seem to behave in a more fickle way. The tray of GBalds got mostly sprays of fortified water and their root systems were on the dry side. But they fared pretty well for 3 years.

The roots of GBalds in pots being pot-bound is obviously one factor that drives deterioration. The roots of GBalds in a tray should be able to roam more freely without strangling themselves. In the following, we will see how four GStellas (below) may have been controlled by their roots. Two GStellas did very well in a tray of scoria and pumice, with no drainage. Growth was slow, but they never lost their nice green colour or did any shrinking. At first glance, it would seem that growing GStellas in a rocky mix is a very good “slow and steady” technique.

In the upper picture, the four GStellas have been in the tray for 15 months. At this point, the two on the left were moved to plastic pots. (September 2019)
In the lower picture, the remaining two GStellas have been in the tray for another 3 years. In over 4 years in the tray, the two have not grown all that much, but their spines are great. (September 2022)



The upper picture shows two GStellas (arrows) round and in good shape. The two have been in the pots for 29 months or about 2½ years. The one on the right produced one flower in March 2021, after 18 months in the pot. (February 2022)
The lower picture shows the two GStellas at 37 months looking flatter, having shrunk a bit. Interestingly, the small Gymno in the middle is behaving in much the same way. The two GStenos at the back didn't shrink, but they discoloured a bit. (October 2022)

As for the two GStellas that were potted up, they grew fine for a while. One even flowered. And at about 3 years after potting up, they are now shrinking with a less healthy green. Well, it appears that most Gymnos go downhill after about 3 years when grown in a pot. Like clockwork.

The GStellas in the tray are still looking good after 4 years. It's possible they may start to shrink in the future, but they have not done so yet. So the real lesson may be this: In the tropics, rocks in a tray is adequate for growing GStellas slowly, while GStellas in a rocky potting mix will go bust after 3 years. And the key difference that we can exploit to grow them better is this: The root systems of the GStellas in the tray have more space to roam.

The two GStellas out of their pots, mid-November 2022. It's no surprise that they aren't happy in the pots. The lumps at the bottom of the pots have hardened and would have trouble getting properly wet with water sprays alone.

Part of the problem with these Gymnos in their plastic pots is the hot tropical climate of urban Klang Valley. Water evaporates very quickly on a hot day, and these specimens get direct sunlight for a few hours on a clear day. The two GStellas, if you look at the picture above, grew their roots towards the last bits of moisture. Chasing after water. This caused the root system to bunch up near the bottom of the pot. Compacted and strangled. Hotter days then baked everything into one single lump.

Another example can be seen in the Flowers and Forcing Flowers Part 2 chapter. Two PClavs had root systems with different shapes even though they were once offsets that came from the same mother plant. These cacti were all chasing after water.

Even though the GStella tray dries up as well, that environment was apparently better for the GStellas' root systems compared to plastic pots. The roots in the tray had more space to roam. On the other hand, a somewhat similar tray setup did not work for those small GBalds. This is not really surprising, since GBalds are generally less robust compared to GStellas.

The environment for cactus root systems will have to be improved if we want to keep them in their pots for more than 2 or 3 years in the tropics. Some solutions may be risky. For example, rich and moist soils will attract bugs. One simple solution is to grow such small cacti in wider containers instead of standard pots. Ultimately, roots still get jammed up and still need refreshing.

Perhaps we just need to be disciplined enough to repot them every so often.

Unravelling a Tangled Mix of Ideas

Growing GBalds (and Gymnos in general) well is not a solved problem. I have a proverbial bag, and inside is a tangled mix of ideas based on observations. Identifying new roots as a key influencer of GBald growth is a big step in unravelling the puzzle and understanding these cacti better.

I've never read any book or article that points out the importance of "new roots"; unfortunately most material is focused on providing growers with recipes. Recipes aren't enough for growers in the tropics, especially in hot lowland locations such as Klang Valley, because the climate appears to bring out all the extremes of GBald behaviour. But it makes for a lot of interesting study material.

Other ideas have been discussed in earlier chapters. Maybe someday we can merge all of them into a coherent model of GBald behaviour so that we can better predict how they will act.

A small GBald grew well in rich soil with a weak root system. Maybe it wasn't primarily due to the nitrogen in the soil. I would pin this on new roots now. Rich soil allowed a lot of new roots to grow, driving strong stem growth. Unfortunately it is difficult to keep roots healthy for a long time in a rich soil mix. It's also possible that shrinking may cause a root system to start dying off, but it's difficult to study something that's underground. It would be good to gather much more data on how GBald roots grow and evolve inside a pot.

A mature root system is needed for flower production. This idea is an extension of mature growth being the part of a plant that is capable of flowering. Several of my large PClav and PMag specimens can produce flowers even when somewhat pot-bound. But compared to GBalds, they are in larger pots and thus the root systems may be in fair condition. This is not relevant unless you are planting GBalds in large containers, and if you do that in the tropics, you will attract a lot of bugs.

Cutting off the root system leads to flower bud production. This happened to the top part of the old and large GSteno that I cut in half. It may be hormone-related. This is not relevant to GBalds, since they are free-flowering when mature and growing strongly. But finding a reliable method to force other Gymnos will be very useful indeed. I repotted my old and large GStella in May 2022, but no buds. Fickle, these Gymnos. The next step is to replant it with almost all roots removed.

Foliar feeding is more of a recipe. Without hormonal signaling, no amount of nutrition appear to have an effect on GBald growth. But I do think some nutrition is absorbed even when growth is stalled: When growth restarted on some of those 2021 grafted GBalds, the spines were strong and some spines were unusually thick. So the GBalds may have collected and stored some resources, but without the correct hormone signal, those resources cannot be put into use.

Stress, shrinking and corking. All of this is still huge muddle, of course. But there's just too much talk of *Gymnocalycium*s dying for no reason everywhere. Writers and experts will blame things like overwatering or fungi. Clearly, "dying for no reason" is related to what we have discussed. It may be an evolved self-destruct behaviour useful in its natural habitat: Crash and die after a few years so that offsets or seedlings can take over the spot. Which part is responsible for the self-destruct signal? This behaviour may be controlled by the root system, which may also be dying off as well. While we may be able to solve this by refreshing the root system, such behaviour needs further study.

A Work in Progress

This GBald ex-graft, which detached from its rootstock in January 2020, was repotted at the end of September 2022, refreshing the root system in order to improve its health. Here it is about 1½ months after repotting. All of its existing offsets have been removed, but a new offset can just be seen appearing near the base (arrow). Renewed growth. The upper green portion of the stem is looking healthier too. (Nov 2022)

As of November 2022, most of my GBald specimens have been repotted. Almost every GBald is showing growth. But it did not work for some specimens. Old GBalds, such as the GBald ex-graft (picture above), also benefitted. Growth is now stronger; this should be reflected in sustained flower production in the coming months. Not bad for an 8 year old GBald. More importantly, those new roots may help to keep this GBald going for many more years.

On the surface, repotting as a solution has been deceptively simple. Most growers are more familiar with applying recipes on their plants. A bunch of cacti got pot bound and are now growing again because they have been repotted. There’s not much to it, right?

Recipes do not tell the whole story. Relying on recipes without understanding what you are doing is very restricting. Identifying new roots as important allows us to take additional steps to improve repotting. I am now very eager to remove roots when repotting. No more treating those roots like fragile and precious artifacts to be saved. I choose new callus tissue over old roots.

With the new emphasis on (A) new roots, and (B) improving the root system environment, we are no longer bound by traditional recipes. There is a huge scope for experimentation. Still, it won't be easy to create something that allows GBalds to grow well for many years in an environment that is hot and humid and has occasional heat waves. Baked potting mix is a major issue, as we have seen. This is the challenge that growers like me face in urban Klang Valley, Malaysia.

For cacti with very strong root systems, I am starting to think about 'wet' cultivation techniques again, including simple hydroponics like DWC. But all we really need may be just the cactus in a bit of standing water (see the pictures below.) This "PMag in a pail" experiment was done on a lark in February 2022 because the root ball was so thickly matted. The performance of this PMag was an early hint of the need for root growth as the key to attaining good stem growth.

New roots may be the key to unlocking the potential of GBalds and *Gymnocalycium*s. In general, if we can better control or exploit hormonal signaling in cacti, there is a good chance that we will be able to reliably grow healthy Gymnos everywhere. ♦

Left: Rewetting the root ball of a small pot-bound PMag. I think it produced only one flower before becoming pot bound. After rewetting, a little water is left in the pail so that it dries up in a day or two. While the root ball is still moist, more water is then added. I would describe this as "swampy conditions." (Feb 2022)
Right: The PMag after 7 months of strong growth. Standing water in a pail did not kill the PMag or destroy its root system. It was not heavily fed, so algae was only a minor issue. The well-wetted root ball never fully dried up between waterings. It turns out such a root ball is not a problem for this PMag outside of its pot. (Nov 2022)

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