

Roots in Rocks



Removing several rooted GBald offsets for planting into individual pots, August 2020. These have been growing in the disposable bento tray since March 2019.

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

Introduction

The following is a catalogue of some rocks-only cultivation experiments that I have attempted. Such experiments started after I read *The Stone Eaters*. My primary objective was to grow better root systems leading to healthier and stronger plants, and to reduce organic soil-based bug threats like fungus gnats. I did not simply follow what was prescribed in *The Stone Eaters*; instead, I embraced some of the concepts and started testing using simple trays. For long term cultivation, I just wasn't ever going to go with deep pots full of heavy mineral soil – I needed to regularly inspect specimens for bugs and heavy pots are going to hinder such activities.

Nicknames for Scientific Names

PMag = *Parodia magnifica*

PClav = *Parodia claviceps*

GStella = *Gymnocalycium stellatum*

GBald = *Gymnocalycium baldianum*

MGeo = *Myrtillocactus geometrizans*

GSteno = *Gymnocalycium stenopleurum*

This naming scheme is purely for convenience. Just think of them as webchat nicknames.

Preliminary Experiments



Specimens in two trays of mostly scoria, July 2018. The round pots of GBalds have some soil layered below the scoria, so those plants were not in a pure rock-only mix.

Experiments with trays started around April 2018 when GBalds and GStellas were recovering from their dormancy-like behaviour¹. The red tray with three GBalds in the picture above was planted in April 2018. The tray has some drainage holes which doesn't drain much water because water has nowhere to go under the tray. The GStellas in the clear tray were planted in June 2018. This tray has no drainage, and the medium is scoria with some sprinkled LECA balls. Nutrition was supplied by regularly spraying with fortified water, and via the scoria breaking down.

Another clear tray was filled with pebbles and a few older GBalds were planted so that they can grow out roots again (see picture on the next page.) This tray did not work well, because pebbles cannot absorb water, so the tray either looks wet or dry, but not moist. In addition, the wet condition attracted an infestation of white flies. So, pebbles do not work well as a growing medium. By contrast, scoria are porous and can absorb water.

The three GBalds in the first clear tray (above picture) died, but I think they were too weak to produce new growth and they may not have survived even with perfect care. As long as you don't spray too much water, a tray with no drainage can be used for growing GBalds and GStellas in rocks.

¹ See the chapter on Complications of Shrinking for the details.



A clear plastic tray with no drainage, filled with pebbles. A tray of pebbles wasn't a very good medium for growing GBalds. (May 2018)



The GStellas looking plump and green in November 2018. The tray is wet, having just been sprayed. A few offsets were planted in the tray to let them root. In the upper right corner is a PClav offset from the big PClav. The other three are GBald offsets. One of the three GBald offsets failed due to rot because I sprayed too often. After reducing water sprays, I had no further problems with GBald offsets rotting.

A PClav Offset in Scoria

This PClav offset was detached from the big PClav and planted in the clear tray in October 2018. The offset produced a nice root system in 3 months (pictures below.) Another benefit of rooting PClavs in scoria is that the spines on new growth is dense and long.



Closeup of the rooted PClav offset (arrow) in January 2019, just before removal. It has grown slightly larger versus the November 2018 picture on the previous page.

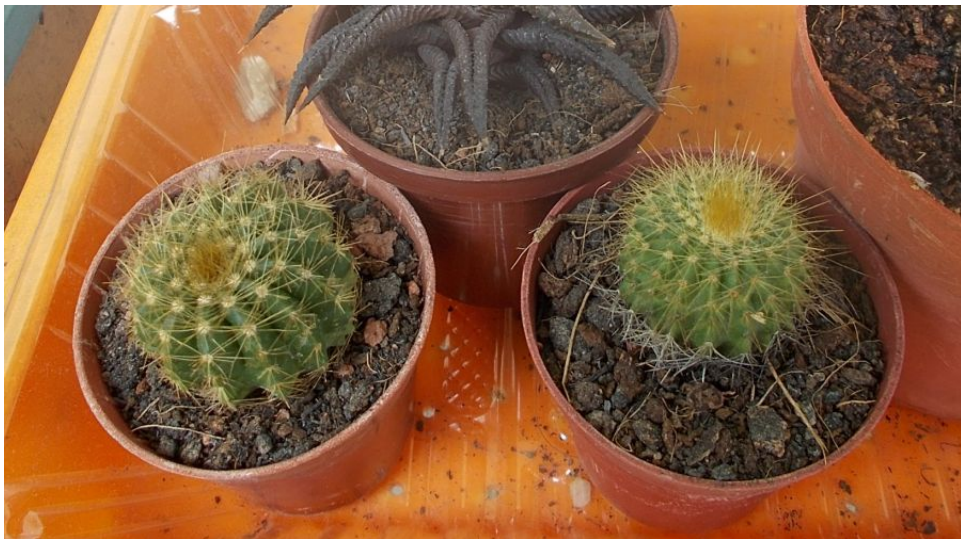


The roots of the specimen after it was pulled up. The roots are white and healthy and a lot of scoria has stuck to the roots. (January 2019)



At left (arrow) is the specimen that was in the clear tray. At right is a commodity cactus PClav that I bought around this time. For the latter, I had all its roots removed because of mealybugs. (January 2019)

Look carefully at the tops of both specimens and compare their spines. While the commercial specimen looks presentable enough for a commodity cactus, the new spines on the PClav specimen from the clear tray is longer.



The two PClav specimens after potting up in 2 inch plastic pots. The rooted offset is at right. The potting mix is soil plus scoria. (January 2019)



The specimen in September 2019, after about 8 months of growth.



The specimen after being pulled out of its pot. It's fairly healthy although in 2019 I sprayed my plants only once or twice a week. As such, this specimen was not getting ideal amounts of water and nutrients for growth. It was later put into a 2½ inch pot in a layered soil mix with lots of scoria. (September 2019)



The PClav specimen (arrow) about 11 months later, in August 2020, still in its 2½ inch plastic pot. I think more scoria helps to produce long and dense spines.

PClav offsets are very easy to grow. Avoid attracting fungus gnats by not having wet organic matter around, then spray water to remove dust and deter spider mites and you'll be okay. Layers of pure scoria in the soil mix will absorb some water so that any soil isn't saturated for too long. The water retained in the porous scoria will provide moist conditions for roots to thrive. It's also a rocky mix, so there is good air exchange.

From mid-2020 onwards, I am spraying my plants nearly every day with fortified water, if there is good weather. With a soil mix that is mostly scoria, there is little risk of over-watering the specimen. As you can see from the picture above, the PClav specimen has responded very well to this new cultivation practice. It looks rounder compared to the pictures from September 2019 on the previous page because its girth has expanded significantly.

In summary, small PClavs can be pushed to grow quite fast under ideal cultivation conditions, and you'll get nicer spines and healthier plants by growing them in a mix that is mostly scoria.

GStella Offsets in Scoria



This picture was taken when mostly-rooted GBald offsets were removed from the empty half of the tray. (March 2019)

These are the GStella specimens from page 2, recovered and growing well after nine months in the clear tray. Three shrunken GBalds that were put in the tray did not recover from dormancy-like behaviour, turned brown, and died. Since the GBalds did not turn into a watery brown mush, the tray was still somewhat clean. GStellas have a very tough skin and I suppose they are very tough.

After the demise of the GBalds, the empty half of the clear tray was then used to root offsets, mainly GBald offsets. As long as conditions are not wet for too long, a tray of scoria is a good medium for rooting cactus offsets. It probably won't be the fastest way of growing cactus offsets, but as you will see in later sections, GBalds offsets are able to grow very nice root systems in scoria.

In the above picture, you can see the sprawling root systems of the GStella specimens. A potting medium that is mostly porous rock appears to promote the growth of thick roots.



Closeup of one GStella specimen showing the thick roots in detail. (March 2019)

As you can see in the picture above, the GStella roots were thick and coarse. The upper part of the scoria dries faster, so the bulk of the roots actually grew along the bottom of the tray, where it is moist longest. In time, the scoria breaks down and produces a layer of rock powder at the bottom of the tray (see pictures on the next page.)

GStellas grow rather slowly and they can be left in a pot for years. Promoting thick and tough roots on specimens may help to keep them healthier in the long run. With less organics in the potting mix, it's not a great place for bugs to stay. The rocky mix probably cannot support a lot of bugs either. Remember, these specimens will be in their pots for years and if the pots are full of bugs, your other specimens will be in constant danger.

Using rocky potting mixes is a great strategy when you are growing cacti in the hot and humid tropics and you do not use any systemic insecticides.



Side closeup view of the clear tray. (March 2019)



Closeup of the underside of the clear tray. Scoria powder has accumulated at the bottom. (March 2019)

GBald Offsets in Scoria



The clear tray after spraying with water, November 2018.

Before late 2018, I had harvested many GBald offsets in order to grow them indoors, near a window. As discussed in previous chapters, this did not work out well, because scale insects still managed to get at them through a window with a mosquito screen, thanks to the wind. I also had occasional problems with fungus gnats. In addition, the indoor GBald specimens grew long and soft stems. As such, it wasn't a good solution for propagating GBalds via offsets.

So in addition to growing cacti in scoria, I started to experiment with rooting GBald offsets in scoria. This has to be done outdoors², to keep the GBalds globose³ and firm. Of course it is possible to propagate GBald offsets using a partly organic soil-based medium, but with scoria the threat of bugs is very much reduced.

With a no-drainage tray, there is risk of over-watering leading to wet conditions. But with some practice, it was possible to keep the tray mostly moist. Only one GBald offset died of rot. A minor problem was that the top layer of LECA balls made it difficult for small GBald offsets to produce roots. So in March 2019 I moved the rooted GBald offsets to an improved tray.

2 I don't have any big plans to use artificial lights to grow or propagate them indoors. My priority is to keep things simple, as far as possible. Cultivation methods have to be accessible to the average grower to be widely useful.

3 Spherical or ball-shaped.



The tray in January 2019, with more GBald offsets added. The bottom three GBalds are of a lighter shade of green; these were probably from indoors.



In March 2019, just before the rooted GBald offsets were moved to a new tray.



Rooted GBalds after removal from the clear tray. Three of them look somewhat cylindrical because the three had been indoors for a while. (March 2019)

The above picture and the pictures on the next page shows the improved setup. This is a disposable bento container and there are still no drainage holes. Large LECA balls were a hindrance for small GBald offsets, so they are not used here. Bits of sphagnum moss were placed with the roots of each small specimen so that the roots are moist for a longer period of time. Soria is porous and absorbs water; it also freely drains water. Therefore, wet conditions are largely avoided.

A short length of PVC tubing was glued on to enable the tray to be manually drained. In practice, manual draining was never needed for this tray. I have manually drained other trays on rare occasions due to wind-blown rain⁴.

Look closely at the lower left specimen – it looks like a tap root system. The main roots are thick and tough. GBalds do not seem to produce such a root system when grown in soil with organics. In organic soil, GBalds grow a lot of fibrous roots that are thin and weak. Of course, with some care it is still possible to grow nice GBalds in organic soil. But for growers like me who do not use systemic insecticides and other chemicals, organic soil is a high risk strategy. Why not grow GBalds in scoria and get strong and tough root systems?

Progress of this tray of GBalds is covered in the chapter on Propagation Via Offsets. This chapter's focus is on the condition of the roots. We will look again at these specimens in a later section.

⁴ I have disposable plastic pipettes (usually used for measuring liquid fertilizers) to help with this.



Populating the new tray. Moist sphagnum moss was cut into small pieces, then small clumps of moss were placed with the roots of each GBald specimen. The tall GBald at right is a specimen from indoors. While it is possible to grow them indoors, small GBalds grow tall and somewhat soft with little or no spines. Outdoor specimens maintained their globose shape, they feel firm, and had better spines. (March 2019)



The fully-populated tray, after being sprayed with water. (March 2019)

Transplanting Rooted PClav Offsets



Removing a rooted PClav offset from its tray. (May 2019)

As far as growing cacti in rocks is concerned, this isn't a particularly good experiment, because there was a layer of soil on top of a layer of scoria. Also, these specimens did not get optimal amounts of water or nutrients. PClavs are easy to grow, and I wasn't in a hurry to expand my collection of PClav specimens. I was more interested in improving the health of my GBalds.

These PClav offsets were harvested and planted in January 2019. In about 5 months and under non-ideal conditions, they did not produce a lot of roots (the above picture and pictures on the following pages.) But they were somewhat healthy and growing slowly but steadily. The root systems of the two specimens that were removed did not look any different from specimens grown in soil. The other three are still growing in the tray as of November 2020, but I suspect the root system of PClavs is not as variable as the root system of GBalds.

From mid-2020, the specimens in the tray were sprayed more often, so they got more water and nutrients. The result was faster growth and yellow spines, so they looked more like normal PClavs compared to the above picture. Well-grown PClavs in a soil mix may look just as good. Currently, I don't know of any clear advantage in growing PClavs in scoria over growing them in a soil mix. A more interesting challenge is to optimize growth speed, since a large mature PClav specimen is capable of the sustained production of many flowers in a hot tropical climate.



The roots were clinging to scoria along the bottom of the tray. (May 2019)



Preparing to pot up two PClavs. (May 2019)



A closeup side view of the two specimens. Subjectively, their roots do not look any different from PClav offsets rooted in a soil mix. (May 2019)



The two PClav specimens after potting up in May 2019. You can see them pictured 15 months later on page 7.

Transplanting Rooted GStella Offsets



The GStellas (bottom row) with very nice newer spines. (September 2019)

After 15 months in the clear tray (picture above), the GStella specimens were running out of space. All four have grown, with strong white spines on new growth. In September 2019, two of the four were removed from the tray to be placed into regular plastic pots.

Two specimens were carefully removed from the tray (pictures on the next page.) Two root mats have formed, along with many long strands of roots that stretched quite far. A lot of roots have grown onto scoria and some LECA balls. The roots were stuck fast onto the rocks like they were glued on. The root mats and long root strands were also stuck to the plastic tray and had to be carefully detached.

GStella is a beautiful species with strong, sharp spines. Specimens are very tough and largely trouble-free, apart from that one time they joined the dormancy-like behaviour of GBalds by shrinking and turning yellowish for a few months. One disadvantage is slow growth. The other disadvantage is that GStellas are not interested in producing flowers in a hot tropical climate.



One GStella, lifted out of the tray. (September 2019)



The same GStella, showing the bottom root mat. (September 2019)



Another view, showing long root strands that stretched quite far. (September 2019)



The two specimens after removal from the tray. A lot of scoria and many LECA balls have stuck fast onto both root systems. (September 2019)



A bottom view of the root mats of the two GStella specimens. (September 2019)

As you can see in the picture above, the root system of the GStella at left circulated along the bottom of the tray, where it is moist longest. It appears that GStellas love a very rocky mix. Specimens in the clear plastic tray were sprayed only once or twice a week during this period. So even with short bursts of moisture, the GStellas were able to maintain a strong, extensive root system.

If I want to treat cacti like hardy plants that can thrive in desert-like conditions, this is the type of root system that I want my specimens to have. Not the masses of fragile fibrous roots that GBalds produce in organic soil. Fibrous roots will suffer if you try to treat specimens like hardy plants. So if we have the ability to influence how the root system of a cactus specimen develops, we should direct the specimen to produce a root system that is robust and tough. And it appears that we need to grow cacti in rocks to achieve that.

Commercial operations may not need or even want to do this, mind you, because they focus on mass producing plants to a saleable size in the shortest possible time under controlled conditions. But hobby growers like you and me will benefit if we can grow cactus specimens with the best possible root systems. Therefore, we need more experimentation on cactus root systems.



The root systems were trimmed and largely cleaned of rocks to force both specimens to regrow new roots in their new pots. (September 2019)



Both specimens were put in layered mix. The middle layer of soil can be seen in the pot at right – the top scoria layer has not been added yet. (September 2019)

Transplanting Rooted GBald Offsets



It's starting to get cramped in there. They look healthy enough – there are plenty of spines, they look round and feel firm, and their colour is excellent. (August 2020)

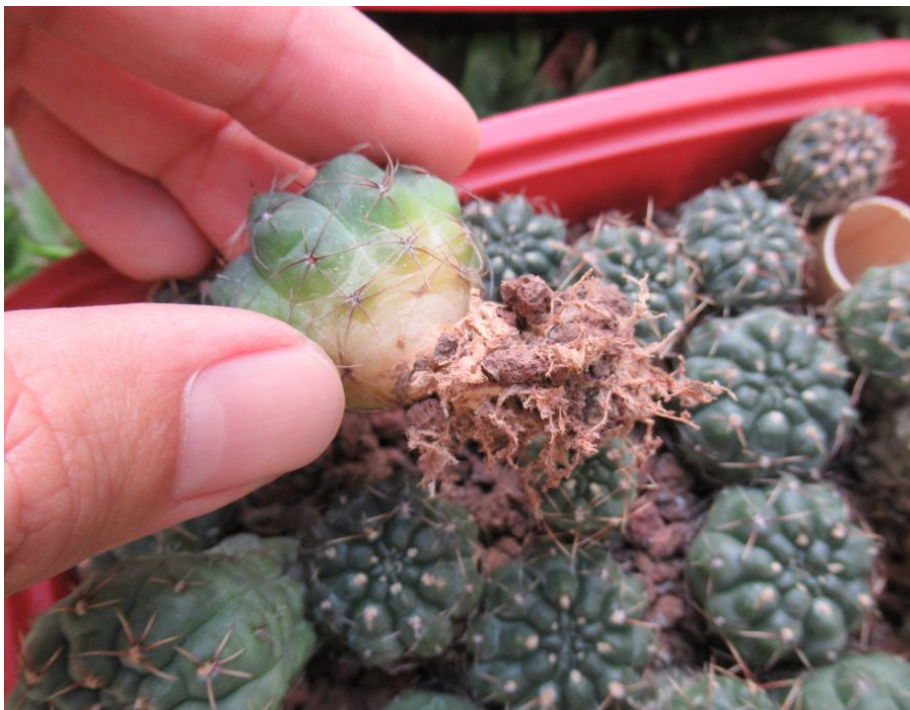
After about 17 months, the bento tray of rooted GBald offsets that was planted in March 2019 looked cramped. I had three options: leave them to grow more, pot them up, or graft them. I decided to pot a few up because I have several GBalds in layered mixes of mostly scoria that are doing very well. One GBald, still in its 2 inch pot, has produced 7 flowers (June–October 2020) and more than one seed pod. That's very impressive, considering a bunch of GBalds that I saw at a plant nursery in November 2020 were much more than 2 inch in diameter and all of them did not look like they had ever flowered. So I needed more specimens in rocky mixes in order to get more lifecycle data.

Such a tray of small GBalds is a very convenient high-density planting. Here are 30 healthy small GBalds, and if you hold back the NPK fertilizers, you can probably keep them in the tray for a few years. These days I am interested in the lifecycle of GBalds, so I am leaving offsets on specimens. When the mother plant croaks, I will harvest the offsets and start a new tray of small GBalds. If the old GBald has been shrinking well, then it should not be too soft or juicy and when it weakens and dies, much of the old stem will dry up quickly and attached offsets should survive just fine⁵ – just like specimens in habitat.

⁵ Or not. In late November 2020, one old and weak GBald died in an undesirable way. Bugs got to it first and turned everything into a blackened, rotting mess. Maybe the tropics is too humid to let it go the “dry husk” route.



Preparing to transplant some GBalds. (August 2020)



Removing a small GBald from the tray. (August 2020)

In addition to a layered mix with some soil in the middle sandwiched by scoria, there are discs of nappy liner and a layer of fine burnt soil aggregate above that to block the entry of bugs⁶. I also added small clumps of sphagnum moss below the soil to provide extra moisture. Three pots had some eggshell flakes added as an experiment. As of November 2020, I have not seen any difference in growth from the use of eggshell.

The GBalds have grown a lot of roots and the roots were all stuck to scoria and the tray. So there is actually very little loose scoria – everything is glued together into a single slab. Removing specimens will undoubtedly cause some damage to roots, but since the roots dry out all the time in the tray, some damage is no big deal. A few large specimens were loosened and carefully pulled loose from the tray without damaging too much of their roots.

Below are the six small GBalds that were removed from the bento tray. The root systems look fabulous. Many had one major root that look much like a tap root. I have never seen tap roots on GBalds that are grown in regular soil mixes. The roots were strong and tough, not soft and fragile. Most roots have grown onto scoria.



Small GBalds grown in scoria have fabulous roots. (August 2020)

⁶ Read earlier chapters if you are new to any of this.



A closeup view of two of the GBald specimens. (August 2020)

As you can see in the picture above, each small GBald has one main root that is tapering, almost like a tap root. I don't see such roots on GBalds in regular soil. There are a lot of branches and the finer roots have stuck onto scoria and glued everything together into a clump of roots and rocks.

Since these specimens are subjected to bursts of moisture and also dry conditions in the tray, such root systems are able to survive and thrive. In the past, I've had GBalds lose all their roots in a soil mix. Unlike *Parodia* specimens and other *Gymnocalycium* species that I have, it appears that GBald root systems are rather malleable and variable.



GBalds roots grown in soil look fibrous and fragile. (March 2017)



Potting up the GBald specimens. Sphagnum moss was placed near the bottom of the pots to encourage roots to grow down to reach moisture. The bottom three pots have had the middle layer of soil (mixed with scoria) added. A layer of scoria will be added as a top layer, so in theory no wet soil will ever touch the stems. (August 2020)



A closeup view of the long, tapering root system of one specimen. (August 2020)

A GBald with a strong tap root may prove to be healthier than a GBald with a lot of fragile fibrous roots. We shall see; these six specimens will be the guinea pigs. As of October 2020, they are growing strongly and steadily (see pictures on the next page.) After 2 months, roots have already penetrated the nappy liners at the bottom of the pots. Since I have one GBald in a 2 inch pot that is flowering steadily since June 2020, these specimens will be left to grow in their 2 inch pots for as long as possible.

The results suggest that the challenge in growing GBalds is to *balance* stem growth and root growth, because there may not be enough resources to maximize both. For example, GBalds in rich soil may grow nice stems, to the detriment of the root system.



The six GBald specimens in their pots. (August 2020)



The six GBald specimens after 2 months, at the end of October 2020. The pots in the upper row have extra eggshell flakes. All six specimens are growing well.



Roots were already peeking out of the bottom of the pots at the end of October 2020, thanks to the specimens' strong root systems. The tray is kept clean and so far no gnats or mealybugs have been found under the pots.

Transplanting GBalds Grown in Scoria



Three GBalds grown in scoria, after about 2½ years. (September 2020)



This was how they looked at the start of the experiment. (April 2018)

This is a tray of three GBalds that were put in a bento tray when they started to recover from dormancy-like behaviour in April 2018. Although small holes were cut in the bottom of the tray, in practice drainage did not work very well as water would pool under the tray. But that wasn't a problem as spraying doesn't keep them wet for very long. In the tray was scoria, and a piece of nappy liner was glued onto the bottom of the tray.

Although growing GBalds in scoria produces great root systems, there are downsides that complicate matters. For this tray of three GBalds, the specimens didn't grow a whole lot in 2½ years (see the pictures on the previous page.) All three were growing rather slowly. Only the middle-sized specimen produced a few flowers. So growing GBalds in pure scoria with limited water and nutrients won't give you a lot of cactus flowers.

On the upside, the specimens managed to channel resources into producing robust root systems. But can we get strong stem growth and strong root system growth in GBalds at the same time? Non-grafted GBalds may have difficulty doing both, because plants that conduct CAM respiration such as cacti have limited resources. If we cannot have strong simultaneous stem and root growth, then one obvious solution is to grow out a strong root system first, then switch focus to stem growth in order to get lots of flowers. Alternatively, we can try to target better-balanced stem and root growth by experimenting with rocky potting mixes and cultivation techniques.

One problem that arose was spider mites hiding under the two large rocks. Below is a picture of what is probably spider mite webbing, seen after the rocks were removed. So spider mites could shelter from sprays of water under the rocks. The rocks act as weights on the scoria so there is some pressure on the roots – it was supposed to simulate cacti growing in gaps between rocks.



Wispy webbing under the two rocks – probably spider mite webs. (September 2020)



Lots of thick roots have penetrated the nappy liner. (September 2020)



The root system of the small GBald. (September 2020)

If you look at the root system of the small GBald in the previous page, the obvious conclusion is that the specimens spent a lot of resources constructing their root systems. There are a large number of thick roots, all of which lie along the bottom of the tray, stuck to the nappy liner. Perhaps under such conditions, these specimens opt not to spend a lot of resources on growing their stems.

Since growing GBalds in scoria can get us strong root systems, can we replace scoria with something else and still get strong roots? We will have to conduct more experiments. The material should be porous and be able to stay moist for a while. I have perlite in stock, but these days I am quite reluctant to use perlite because I have plenty of scoria in stock. Also, I hate dealing with wet perlite. Nappy liner can help keep conditions moist for a longer time, promoting the growth of roots (see pictures on the next page.) But I would not use nappy liner as the primary potting medium.

Can GBalds produce strong roots if we eliminate the rocky potting medium? Personally, I think it is difficult to duplicate the results without porous rocks. I have attempted DWC (deep water culture) of GBalds in the past. GBald roots growing down to the nutrient solution are always flimsy and weak. The roots likely need moisture cycles to toughen up. Moisture cycling is not possible with simple DWC pails – we will need a proper hydroponics system. So we might as well stick to scoria.



The lower part of the crested GBald is shrinking. This GBald did not produce a very strong root system, possibly because the crested head takes up too much resources and there is little left for the root system. GBald is not a very long-lived species; do not regard this specimen as priceless. It's just a GBald with a damaged growing point. Keeping this crested specimen alive and healthy will be an uphill task. (Sep 2020)



Two GBalds wet after a bit of cleaning. (September 2020)



The nappy liner probably led to a dense thicket of short roots. (September 2020)



A closeup view of the cleaned-up roots of the smaller specimen. (September 2020)



The three specimen potted up, with the old bento tray behind them. (Sep 2020)



The two non-crested GBalds wasted no time after repotting. Here they are with flowers (the smaller one is at the lower right), just under 2 months later. (Nov 2020)

Growing GBalds in rocks – specifically porous rocks such as scoria – is great for their root systems. Porous rocks provide the right kind of airy moisture cycling environment for strong roots to flourish. But when limited resources are put into growing roots, stem growth slows and flowers are few or non-existent. Better feeding can probably improve matters and make a balanced growth strategy more viable. But if we want lots and lots of flowers, then a phased scheme with different rocky mixes ought to be worth trying.

Balanced Growth for GBalds



Remember this GBald in a 2 inch pot? This specimen is visible as the smallest GBald in the picture on page 2. Here it is with 2 flowers in September 2020.

A small GBald in a layered mix of mostly scoria is happy in a 2 inch pot (above picture.) I even got seed pods out of these two flowers. On the other hand, my GBalds grafted in 2019 have aborted numerous flower buds because I suppose they were growing *too fast*. Perhaps GBalds can't do their balancing act well in artificial settings.

I think GBalds could use our help in order to achieve better balanced growth in cultivation. ♦

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