Useful Concepts

An accidental bonsai (2018). This is a Genovese basil plant, a Western kitchen herb. It's not supposed to be very long-lived. This is an old plant, and the trunk looks terrible. It has split and the bark is flaking. Some stems are also dead.

Likewise, for cacti that are short-lived, you will be hard-pressed to keep them in great shape for many years. Many cacti are just green stems – how many regular green-stemmed leafy plants do you know that can live for many, many years and stay in good shape?

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

Things to Think About

Writing is a really useful activity, especially when it comes to writing about the cultivation of cacti in a tropical climate. Many a time, I thought I have understood something, but when I went over the material after a few months, I realized that I was on the wrong path.

Over time, I have taken note of a number of concepts – things to think about – that helped to direct my lines of thought in the right direction. If we understand cactus plants better, we can take better care of them.

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.

It's All Kinds of Green Stems

Some MGeo specimens, January 2019.

Growing cacti means dealing with all kinds of *green stems*. These green stems range from very soft to very hard. MGeos (picture above) are green stems that become very tough with age. MGeos have evolved to live for many years and still look good. Not all green stems are so tough. Many species of *Mammillaria* are green stems that are soft. It's impressive when you think about it: a soft green stem that can live for a few years. Many regular herbaceous plants with green stems do not last forever either. Some will turn woody, such as the basil on the first page, but it won't be as durable as a regular woody tree.

Green stems do not last forever and they are not indestructible. The tropics is hot, humid, and full of bugs – it is better for Nature to evolve fast lifecycles for green stems. But here we are, trying to grow all kinds of long-lived green stems in a tropical climate.

No Leaves Means No Immediate Feedback

Almost all species of cacti do not grow leaves. When checking your cactus plant, you are either looking at the stem or the soil surface. Stems do not give you immediate feedback. On a hot day, you would scramble to water your leafy plants when you see their leaves drooping. And if leaves are *dropping* when the plant is supposed to be green, the plant may be in very serious trouble.

A globular or columar cactus is usually just a stem without leaves – it's not going to be able to tell you of its immediate or short-term needs. The stem tends to show long term changes instead. Since most cacti are also tough plants, a plant may be in trouble but it may still look quite good.

These two PMag specimens have been left with their roots bare for about 7 months, getting only occasional sprays of water. All the fine roots have crumbled away. The stems still look healthy, if somewhat shrunken. If someone only sees the tops of these specimens, they might think the plants are in okay condition. But in reality – no roots for over half a year! Note that newer growth look a bit shiny due to a light spray of household water-based insecticide. (April 2017)

Left: A *Haworthia limifolia* in March 2016. **Right**: The plant in August 2016. This is a succulent with leaves, but the "no immediate feedback" principle still applies here. At left, the plant is not in excellent shape, but it produced a flower stalk. At right, it looks less healthy, has shrunken and some lower leaves are turning brown.

In the above, it's not clear whether the *H. limifolia* plant is in trouble due to the soil mix or it is trying to go into winter dormancy in a tropical climate. By the end of 2016, it had lost all its roots when pulled out and inspected. Such a decline may look obvious when one compare pictures that are 5 months apart, but if you see your plants all the time, slow changes will not set off any alarm bells in your head. When you finally realize a plant has changed, usually the change has become obvious. Whether cactus stems or fleshy succulent leaves, this means long term change.

Left: Looks terrible, maybe it's just resting... **Right**: Once the *H. limifolia* grew new roots, the plant bounced back *remarkably fast* (March & April 2017). In the 33 days between pictures[1], the plant turned green and started putting out a flower stalk. It had also been repotted in a richer soil mix after new roots were seen.

1 I have double-checked the dates of the picture files: 3 March 2017 and 5 April 2017. Express recovery!

In retrospect, the *H. limifolia* may have gone through some kind of dormancy. If so, it wasn't triggered by temperature – it is hot in Klang Valley all year round. Dormancy behaviour may come as a surprise to growers in tropical regions who are used to evergreen plants. Or it may have lost its roots to some kind of rot. So you are watching the plants change in slow motion, spread out over many weeks to months. Is it in some kind of trouble or is it just dormancy behaviour?

When you monitor your cactus plants, you are monitoring medium to long term behaviour. There are no leaves to signal whether your day-to-day care is good or bad[2]. Your cultivation methods will produce visible results – but on the time-scale of weeks, at best. For example, you may just be able to see new growth within a week, but obvious changes will take a couple more weeks. In effect, you are cultivating cacti with a "short-term blindfold". If you shower a cactus plant with daily loving care expecting some kind of immediate response, you may well end up killing it.

Many Cacti Grow Slooooooowly

Helianthus Big Smile™, at 49 days after sowing the seeds (from WHT Wellgrow Seeds), June 2018. You'll never get cacti to grow this fast.

If you are used to fast-growing plants like the dwarf sunflowers in the above picture, you will be in for a surprise when it comes to cacti. Nothing happens quickly. You water and feed your cactus plants, but they look much the same week in, week out. For some really slow growers, sometimes it seems like nothing happens at all. You may begin to wonder if you are growing them right. This is not just about a cactus plant's stem that is slow to change – there is something about cacti physiology that causes slow growth.

2 Simple leaves on some *Opuntia* are fleshy, do not droop, but can dry up and detach. Not much help there.

You've seen what sunflower seeds can do in 49 days. Now let's look at cactus seeds. This is a container (inner diameter 66 mm) with some PMag seedlings, at about 50 days old[3]. The small cluster of seedlings (blue arrow) is another bunch of PMag seedlings, about 2 weeks old. In the container to the right are a few young *H. limifolia* seedlings, at about 5 weeks old. Grown indoors under a lid. (April 2019)

As you can see in the picture above, one has to be really patient when growing cacti from seed. When growing cacti (and most succulents), you should expect various degrees of slow growth.

The reason for this is **CAM (Crassulacean acid metabolism) photosynthesis**, something that all cacti (and most succulents) do. Look up Wikipedia if you want the scientific details, because I will only discuss it in a haphazard manner.

In their natural habitat, daytime is hot while nights are cold. Cactus plants need to breathe, but they will lose too much water if they breathe in the daytime. To survive in harsh environments and conserve water, cacti keep their stomata closed during the day to minimize water loss. This limits gas exchange as well. But plants only get sunlight during the day and they need CO_2 (carbon dioxide) gas for photosynthesis in sunlight. In order to conduct photosynthesis in daytime, CAM plants need to acquire useful amounts of CO_2 from somewhere.

CAM plants evolved to rely on an intermediate compound, malate. CO_2 is taken in during the night when stomata are open, then it is bound with an organic compound to form malate. During the day, an enzyme acts on malate to release CO_2 for photosynthesis. Using this two-phase cycle, CAM plants are able to hold their breath during the day and still conduct enough photosynthesis to survive.

3 There is an awful lot of variability in the PMag seedlings possibly because it was a GBald cross-pollination attempt.

Using this simple model of CAM photosynthesis, we can point out its limitations over C3 or C4 plants that can conduct photosynthesis all the time. A cactus plant can breathe or allow gas exchange all it wants throughout the night, but the amount of CO_2 it can store as malate is limited by the amount of malate precursors that it has. In daytime, it can bask in all the sunlight it wants, but the amount of photosynthesis that it can do is limited by the stored malate. There is a bottleneck, namely the amount of stored malate. CAM plants cannot use all the CO_2 that enters in the night, nor it can use all the sunlight that hits the plant.

The consequence of not efficiently converting potential resources to something useful for the plant is slower growth compared to non-CAM plants. Evolution has traded photosynthesis efficiency for water conservation. Thus gardeners are faced with the challenge of cultivating cactus plants that grow slow, to various degrees.

A pineapple plant grown from a fruit top at 8 months (Sep 2019). Pineapples grow pretty fast for a CAM plant, yet it will take about 2 years for pineapple tops to fruit.

In real life, plants do not precisely follow simple scientific models. Some CAM plants grow quite fast relative to other CAM plants; some grow very slowly. Pineapples are CAM plants that grow quite fast, making them a commercially viable crop. Apparently there are also succulents that can switch to C3 or C4 photosynthesis. When conditions are harsh, a CAM plant can presumably stop growing and wait it out. Some cacti take slow and steady to the extreme. But a large columar cactus can speedily produce an offset because a large plant has access to a lot of resources.

So be aware that “slow growth” is not some absolute quantity that is set in stone. If you are able to maintain healthy cactus plants for a few years, you will get a feeling for their growth speed.

Two views of a plant 15 years apart. I'll identify this as some kind of *Gymnocalycium stellatum* for now. At left, the plant is 1.9 inch in diameter, just after purchase in January 2002. At right is the same plant in March 2017, at 3.2 inch in diameter.

Sure, you can see that the *Gymnocalycium* above has grown somewhat bigger. But growth was spread out over a period of *15 years*. You will not actually notice it getting larger; you can only guess that it is growing because of new growth at the top of the plant. For very slow growing cacti such as this one, it is easier to monitor growth by comparing pictures a few months apart. For the first 10 years or so, it probably did not get adequate fertilization because I thought such an awfully slow growing plant would need less nutrients than normal cacti.

Research on photosynthesis in plants is not something that is done and dusted. Scientists are still working on learning more about C3, C4 and CAM photosynthesis and many papers can be read online for free these days. For example, the following is a very interesting open-access paper:

> Brautigam et al., **On the Evolutionary Origin of CAM Photosynthesis**, Plant Physiol., 2017. URL: `http://www.plantphysiol.org/content/174/2/473`

The paper puts forward the hypothesis that CAM and C3 are closely related, CAM having evolved from C3. Thus it may be possible or feasible to turn CAM plants into C3 plants. This has important economic implications – it may make pineapple farms much more productive. It also opens up the very interesting possibility of fast-growing C3 cacti, for example, via breeding or mutation.

Closer to home, are there ways of circumventing the "slow lane" of cactus growth? Yes, the easiest way to bypass the "slow lane" is to do a *graft*. If you attach a small cactus onto a larger cactus, you are really turning the small cactus into a large combo plant. As long as the two plants are compatible, the resources in the large plant will move into the small plant in order to support the growing point of the small plant. The small plant gets a turbo boost. It's a very cool way of bypassing Mother Nature's limitations. You've already seen what a small piece of GBald on an MGeo plant can do[4].

4 For that one grafted specimen: 22 flowers in 2017. 19 flowers in 2018. Flowers in 21 of those 24 months.

New stock at a Klang Valley plant nursery in Nov 2019. *Mammillaria longimamma* (red arrow) is not commonly offered for sale, but is in stock here. The orange arrows point to three *Parodia*s. This is how PMag, PClav and *P. leninghausii* look like as commodity cacti in 2 inch pots. Can you guess which is which?

Short-Lived Versus Long-Lived Plants

Now that you understand the importance of "slow and steady" when it comes to cacti, let's see how we can make guesses about cacti based on looks alone. It may sound superficial, but it can be useful.

Pretend we don't know a thing about genus and species. What can we guess when we see a cactus plant? Look at the *Mammillaria longimamma*[5] specimens in the above picture. The tubercles are long, thin and looks soft with a thin skin. If you have been observant, small clumping cacti of this kind (usually *Mammillaria*, for example, see the lower left corner of the picture) look small, soft and fragile. We can put these in a *short-lived cacti* group. A common survival strategy of short-lived cacti (and many succulents) is to multiply by offsetting.

Look at the PMag, PClav and *P. leninghausii*. These tend to be solitary at a small size. If a cactus plant depend on a single stem for a long time, that stem will need to be tough. Note that a cactus stem has a single growing point, at the top. Therefore, long-lived single stems will tend to become large and maybe columar. These can be casually lumped into a *long-lived cacti* group.

So if you look at commodity cacti on sale, you can appraise the plants and informally divide them into a short-lived group and a long-lived group. *Don't expect a short-lived plant to last forever* under normal conditions. Instead, you can multiply them by rooting offsets or cuttings.

5 If you check this species on LLIFLE, the page says that *M. longimamma* plants have taproots. A taproot is a further complication if you are trying to grow this species in the tropics.

Splitting cacti into short-lived and long-lived plants is a simple but useful exercise. It helps to shape your expectations of what the plant will do and what you need to do. If say, you wish to grow a large *M. longimamma* with a big taproot, what would you need to do to maximize its longevity?

There are other characteristics that are useful in shaping expectations. Wooly or very spiny plants look beautiful and a few can usually be found among commodity cacti for sale. There is a reason why they are 'wooly'; usually it is for survival in their natural habitat – many are high-altitude species. Some wooly *Mammillaria* look like a large white mound in the wild (although individually they are small plants), trapping a layer of air for insulation in the cold mountainous terrain. However, such an adaptation may not translate well to a hot, humid and dusty urban tropical climate.

Remember, PMag and PClav have shallow ribs and are easy to inspect and clean. Most of the other plants in the picture are *Mammillaria*s or *Echinocereus*. They are mostly small and spiny species. As an urban grower in the tropics, I see PMag and PClav as the only two practical species to buy among the plants in the picture if you are looking for something that will live long and is tough. Being selective about what I buy is how I (successfully) stumbled upon them in the first place.

Although guesswork can be a good first approximation, sometimes it is not good enough. Some groups of cacti may have specific traits that can complicate cultivation in the tropics, even if they look promising at first glance. The picture below shows a problem with a long-lived cactus.

Black sooty mold on a *Ferocactus*, Oct 2000. Glands on areoles[6] of many *Ferocactus* species produce nectar. Ants love to visit the plants for the nectar. Soon, sooty mold will develop and the nectar-producing areoles will turn black. This plant is wet because I was probably trying to either dislodge ants or wash off the black stuff. Although *Ferocactus* are long-lived, I no longer grow them.

6 An areole on a cactus is the bump-like structure from which spines grow. It's like nodes (a botanical term) on a stem of a plant from which buds, leaves or shoots grow. Cactus areoles are often wooly or bristly.

For example, *Ferocactus* initially appears to be a good pick as a genus of long-lived and tough cacti. In western movies that show desert landscapes, they are the large barrel cactus with fierce-looking spines. But try growing them in the tropics and you might run into some serious problems. The first is the sooty mold issue, as seen in the picture on the previous page. You can't beat sooty mold in the humid tropics. When a mature plant starts to produce areoles with nectar glands, those areoles are not going to stay a pristine white for long. It's hard to find *Ferocactus* without nectar-producing areoles because as tropical urban growers, we are usually stuck with a limited selection of commodity cacti.

Secondly, stressed plants can get infested by scale insects. Now you have to clean the bugs from a plant with wicked-looking spines. On some *Ferocactus*, the spines even interlock to form an almost impenetrable defensive nest. You may have to resort to systemic insecticides. Such cultivation methods might not suit most small-scale urban growers in the tropics.

Shortcuts have flaws, thus the next step is to learn about all types of cacti, that is, more knowledge. There is no need to remember anything; you only need to browse the many genera[7] of cacti and then read about different species from time to time. Bit by bit you will become more familiar with cactus plants. In the Connected Age, you can look up detailed information, say on the LLIFLE site, at any time. And if you have some success with cultivating cactus plants, it is easy to soak up a lot of information without you even realizing it.

Ecological Niches Means Wide Variation

Learning about cactus plants in detail inevitably means dealing with scientific names. This is in the realm of taxonomy in biology. It's a large field with a huge number of rules and a lot of culture.

I consider myself an amateur urban gardener, therefore I am not going to use scientific names in a formal way. As a simple gardener writing an essay, I choose not to write the scientific name for GBald as *Gymnocalycium baldianum* Speg.[8] in an essay just like there is no need for a sane writer to add ® to every trademarked brand name. I prefer to keep things casual here, as long as you know what is what[9]. But remember, scientific papers follow standardized rules so that science can progress in an orderly fashion.

The scientific name system is an excellent scheme for classifying living things, however flawed the system may appear. When you have to classify and name millions upon millions of *different* living things, there is no such thing as nice or simple or convenient. It's not a small thing. Since there are also thousands upon thousands of *different* cacti, we might as well stick to one name list.

I have no problem with the naming system; there are no simple ways of naming thousands of similar, but different cactus plants. Classification changes means that some species may be renamed over the years. There will also be new species of cacti discovered in coming years. All this means that the system of names is a living document.

And then we are also caught up in the glorious eternal battle between lumpers and splitters.

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7 Plural of genus. It's sort of a group of similar species.

8 'Speg.' is short for Carlos Luis Spegazzini (1858–1926), the botanist who published this valid name.

9 Though sometimes I wonder how far mass-produced 'domesticated' cacti have changed from their wild counterparts.

Left: Upper portion of a *Opuntia cochenillifer* in somebody's garden in Klang Valley. It's probably more than 15 feet high (Sep 2019). **Right:** *Opuntia microdasys* on sale in a 2 inch pot. The small pads are too soft to support a tall or heavy plant (Feb 2018).

Lumping often results in a genus with numerous members with wide variation such as *Opuntia*. To the average urban gardener, sometimes it may be suprising to find out that both large tree-like *Opuntia* and small soft *Opuntia* (see the above picture) are in the same genus.

Splitters prefer to create two or more genera over a single genus. For example PMag (*Parodia magnifica*) used to be called *Notocactus magnificus*, residing in a smaller *Notocactus* genus along with PClav and other species with similar characteristics. *Notocactus magnificus* in turn used to be *Eriocactus magnificus*, in the even smaller genus *Eriocactus*.

I think scientific evidence such as genetic studies will tend to promote lumping. After all, there are very big dogs and very small dogs in all sorts of shapes and colours and they are all varieties of a domesticated wild animal from perhaps a single region. Let the taxonomists have their fun. Our focus here is gardening, not taxonomy. But here is a question: How does a naming system affect what we think about cactus plants?

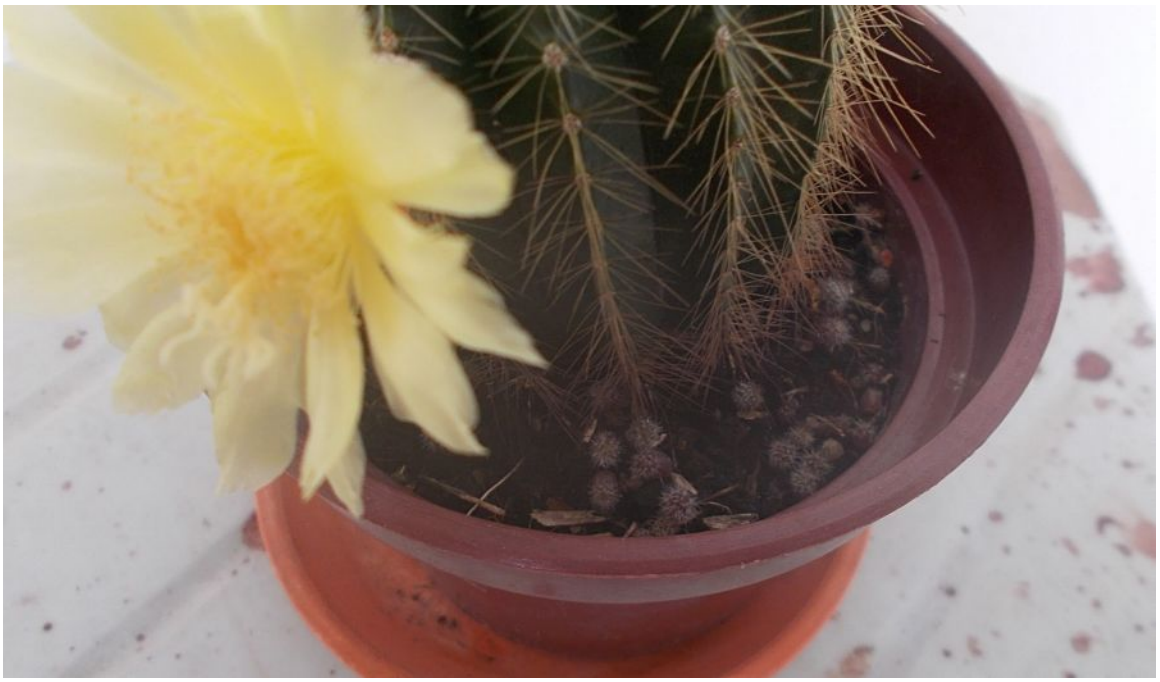
Lumpy taxonomy of cactus plants means that general cultivation tips for a particular genus can be very general indeed. How would one generalize cultivation methods for the two species of *Opuntia* in the picture above? While the two plants have similarities (since they are accepted into the same genus) the tree-like *O. cochenillifer* is almost indestructible while the smaller *O. microdasys* has soft pads that detach easily. So you cannot cultivate them in the same way. It is the closely related groups *within* a genus – for example, PMag, PClav and friends – that you can treat identically.

Why does a genus like *Mammillaria* displays such a bewildering variety of plants in all sizes, shapes and lifestyles? Why is there so much variation? In the case of dogs, it is due to breeding by humans. In the case of cacti, it is the nature of its ecological niche.

For example, a lot of non-desert cacti are found in small, scattered populations in places where grasses and trees fail to thrive. They have impressively adapted to a harsh habitat, but it is really a precarious ecological niche. A *Parodia* in its subtropical habitat may live on a rocky patch of land, but anywhere there is some soil and fertility, it will soon be swamped by faster-growing grasses. If rain and flooding brings in soil, grasses will out-compete cacti and you will end up with scattered patches of the latter where the land is still too poor for grasses. Scattered populations cannot maintain genetic uniformity, leading to variation, and variation will give rise to new species. Many species of cacti are endangered or at risk of extinction because of such scattered populations.

When “ecological niches means wide variation” meets “lumpy taxonomy”, it means that general cultivation notes for cacti is just that – “general cultivation notes”. Try looking for GBald cultivation notes on the Internet, see if you can find any site that tells you about its “shrinking into the ground” behaviour. Nothing – everyone writes the same type of generic cultivation notes for GBald. To them, GBald is just an easy-to-grow *Gymnocalycium*, and the cultivation notes reflect that. Another example: some species of cacti have evolved taproots, but taproots are not a common characteristic.

In conclusion, there are a lot of species-specific knowledge to learn about if we want to fully understand the lifestyles of cactus plants and use that knowledge in improving our cultivation methods. How about a gaming analogy: general cultivation methods will get you only partway in the game. To level up and continue further, you need to look into the species-specific details.



Volunteer seedlings[10] (2 to 3 mm diameter) in a pot with a small PClav specimen, January 2019. At left is a flower in an unusual position for a PClav because the flower was forced and the one bud reluctantly opened after an abnormally long time. Seeds were probably spilled from the big PClav. In the wild, the mortality rate for seedlings is very high and most will not survive to maturity.

10 Seedlings that grew on their own; not deliberately sown or planted.

The Desert is Not a Place of Abundance

Cacti in precarious ecological niches do not only mean subtropical South American cacti scraping a living among grasses and bushes. Cacti in North and South American deserts are also trying to survive in a precarious niche of sorts. The desert is not a place of abundance.

When you watch a wildlife documentary on TV that shows a desert lizard scampering about, it is easy to admire a reptile that is apparently thriving in a harsh habitat. But the overall population of desert lizards can never be very high – a desert is not a rich and benign environment. So the lizards, like cacti, are really just hanging on. If they do poorly, they will become endangered or extinct. If they do well, they can maintain a stable or viable gene pool, and maybe spread out a bit more. But always, surviving in the desert is not easy.

If a desert animal procreates a lot, the mortality rate of its young will be very high. Most will die and only a few of the best will survive. In the same way, a desert cactus plant may produce a lot of seeds, but most of the germinated seedlings will not survive. The few lucky seedlings that survive may have germinated in organic debris, in the shade of larger plants (see the picture in the previous page.)

If you give your cactus plants desert-like conditions, you are selecting for strong individuals. This also means that you are letting many specimens die. Only the best (or a lucky few) will survive.

I don't have any personal pictures of desert cacti in habitat, so the one below will have to do. This was an experiment in growing some tough specimens (*G. stellatum* plants have very hard skins) in pure rock[11]. No drainage holes and inconsistent waterings and feedings means that the specimens live in a kind of boom-bust environment. Not all cacti will do well in this kind of environment.

G. stellatum offsets doing well in red volcanic scoria, covered by some LECA balls, and nothing else save watering and the occasional dilute feeding (March 2019). The disposable supermarket tray has no drainage. Details in a later chapter. These offsets were from the plant on page 8. The picture was taken after moving out some specimens from the empty half of the tray. Note the roots clinging to scoria.

11 Because I read *The Stone Eaters*, a Xerophilia special issue from 2013. We'll discuss it in more detail later.

And so if someone at a plant nursery in Malaysia told you that all the commodity cacti they are selling are desert plants and then give you some general cultivation tips, but you focus too much on putting the “desert plant” bit into practice, you may end up killing a lot of specimens, especially those that are not actually from desert habitats. Whoops.

The classic barrel cactus, *Ferocactus*, will probably do well when grown in rocks. Too bad they have those nectar glands. But not all species from any single genus is suitable for desert plant treatment. Remember – wide variation. Some species may be able to adapt to extreme cultivation treatments better than others. *G. stellatum* is able to handle the scoria tray treatment quite well. Small GBald offsets do not thrive with such treatment. They do not die, but they don’t grow much – they are just hanging on. Larger GBald specimens fare somewhat better, see the picture below.

When trying to imitate desert-like conditions, do not to use too much silica sand or else you would be imitating a sandy beach. I have not used sand for years. Scoria is porous and provides minerals to the plant. It breaks down into a red powder layer at the bottom of the trays that cacti roots like. Not every desert plant treatment will work; your watering and feeding habits will have an effect too.

Three GBalds in a disposable bento container, Oct 2019. The *G. stellatum* tray is at left. The latter specimens have stronger root systems and manages to grow well in pure volcanic scoria. The clear tray has no drainage. The red tray has some small holes poked in it but in practice water just pools under the tray[12]. The GBalds grow more slowly. One of the three is happy enough to start flowering.

12 It’s an experiment. Experiments are fun but should not be regarded as models of excellent care.

If say, as a tropical urban gardener you collect true desert cacti and then insist on cultivating them under authentic desert conditions, then the specimens that do well will likely be mature specimens, usually of good size. Keep in mind the nature of the desert habitat. The smaller or younger the cactus plants, the higher the mortality rate – they are more likely to die in a harsh environment.

As gardeners, we loathe to see our plants die on us, so we have to cancel out the mortality rate with different levels of care depending on the size or age of the plants. Simply put, smaller or younger plants need better care and a more benign environment. And for seedlings, we may end up with something in the spirit of intensive care treatment.

Natural Habitats Versus Human Cultivation

Now that we have a better understanding of their natural habitats, let us turn our attention to artificial habitats, namely the places where we cultivate cacti. This may come as a surprise, but an urban garden in Malaysia can sometimes be *too extreme* for cacti:

Parts of this PMag's skin are lighter in colour. The discolouration is due to loss of chlorophyll (Jan 2020). It is a kind of sunburn or bleaching. These plants face south and are just about sheltered from rain. Maximum sunlight is during northern hemisphere winter months when the sun's track is in the south.

It turns out that conditions can sometimes become challenging even for a large and mature PMag specimen. For most of the year, large PMags and PClavs are able to handle the hot urban tropical weather well. But there are occasional peaks that can stress these large and mature plants and cause sunburn or bleaching. From my observations, such damage is semi-permanent: the patches will recover somewhat, but not fully.

The high stress peaks occur during hot spells in urban Klang Valley. When grass start to turn brown, there is a lot less water in the environment. Reduced evapotranspiration[13] leads to high air temperature – instead of cooling your face, the air heats your face. The walls of houses and concrete driveways also becomes hotter than usual. So environmental conditions can go beyond of what even large subtropical cactus plants can handle. The easiest time to observe this is during the Chinese New Year season in late January or early February. Reduction in traffic during this time always leads to clear blue skies for a few days; more energy from the sun will lead to hotter weather[14].

On one side we have nature: a wide variation of cacti species living in their ecological niches. On the other side is human cultivation. The cultivation of cacti in a tropical urban habitat usually means pots of cactus plants situated outside of a house, sheltered from rain[15]. In a tropical country, we will always fall well short of replicating the climate of their natural habitats. Other aspects of cultivation include the soil mix used for pots, waterings, and fertilization. The challenge is to locate your plants in a suitable location, then provide suitable care so that they thrive.

A small *Gymnocalycium megalothelon* (I think) suffering from sunburn (blue arrow) in the same period (late Jan 2020). It's a new plant that I had recently bought and repotted. The damage is only on the side facing away from the wall.

13 The sum of evaporation from the land surface plus transpiration from plants.

14 This is quite noticeable in Klang Valley, Malaysia anyway. There is less pollution, but less pollution or soot often means fewer clouds and hence, clear skies. I think pollution masks the urban heat island effect to some extent.

15 Heavy rain will tend to wash out nutrients. Soft-stemmed plants will likely rot if conditions are too wet.

Mature PClav (left) and PMag (right) have wooly areoles. Sometimes, new growth is very wooly; these two pictures are from August 2018. Near the top of the PClav, some of the wool shed can be seen between ribs. The PMag does not shed wool so easily but its top is white like the PClav. This PMag is the same one that got sunburned as discussed in the previous section. Normal PMag stem colour is blue-green.

Juvenile Versus Mature Plants

Here is one additional detail about cactus plants that affects your cultivation decisions: there are *juvenile* cacti and there are *mature* cacti and they often have subtly different characteristics. Only mature plants flower[16].

Many plants have a juvenile phase; then they transition into their mature phase after some time. For example, you need to grow an apple tree for many years before it will bear fruit. The classic example of this phase change is the English ivy, whose phases have obviously different forms and habits[17].

You can compare mature and juvenile PClav and PMag by looking at the above pictures and the picture of commodity cacti on page 9. The mature counterparts have wooly areoles, the top or apex area looks like a white patch at times, the spines are stronger, and the skin thicker. Mature PMags additionally have a waxy coating on newer growth that gives them a blue-green hue. Mature PClavs and PMags are tough plants. If you buy juveniles in 2 inch pots, your task is to care for them until they grow into mature specimens. Then they are capable of flowering.

16 Defined as such for the purposes of science, I think. It is one feature that separates juvenile and mature forms.

17 Search for “plant juvenile mature phase” and you will find a lot of information on this. For example, this is excellent: `https://irrecenvhort.ifas.ufl.edu/plant-prop-glossary/03-genetic-selection/17-genetic-phasechange.html`

As for juveniles, I generally regard them as less tough compared to mature specimens. Juvenile cacti have thinner skins, so they may be more susceptible to bug or fungi attacks. Also, smaller pots dry out faster so they need to be watered more often. Smaller juvenile plants have lower reserves, so milder conditions will allow them to allocate more resources to growing larger.

Seedlings, on the other hand, are really in a class of their own. Since seedlings have little reserves and are easily stressed, they require more careful care. Caring for seedlings in an outdoor location in a hot and dusty tropical urban climate is not easy. Keeping seedlings indoors is easier.

Seedlings growing outdoors in a 'protected' environment (Jan 2020). The disposable plastic container is put inside a disposable clamshell burger container[18]. It is put outdoors in a well-shaded place, but that location may still be too hot at times. Three *Haworthia limifolia* seedlings on the left have turned brown, but they are adapting. They were green while growing indoors.

The other seedlings are volunteer PClav seedlings from 2019 (see page 13) that were transplanted multiple times. The smaller ones spent more time being swamped by algae in their previous open containers[19]. The bigger ones were more lucky, they were in pots with less algae. PClav seedlings look like small *Mammillaria*s because their ribs are not well-defined. Compare these seedlings with (1) its parent, the big PClav and (2) a juvenile PClav, seen in earlier pictures.

18 Occasionally, the Ramly Burger vendor I frequent uses a plastic clamshell container.
19 It's hard to control moisture in a small uncovered pot with seedlings – the soil surface is mostly exposed.

A GBald showing some obvious changes (blue arrow) – note the larger wooly areoles near the top or growing point, then compare these to older areoles further down. This may indicate a transition from juvenile phase to mature phase. Most of my healthy GBald specimens start flowering at around 2 inch in diameter[20] (Jan 2020).

At left is one *G. stellatum* that was originally grown in pure scoria; it is now in a pot. The potting mix is layered, with a thick top layer of scoria. The two *Gasteria*s are rooted offsets. *Gasteria*s never seem to be bothered by bugs. At the top is a disposable bento tray of GBald offsets[21] in scoria and bits of sphagnum moss; these survive just fine and have nice spines, but they grow very slowly due to inadequate watering.

(Virtually) Visit the Natural Habitats of Cacti, and More

There are other important concepts or principles, for example there are good reasons for me to use scoria and a layered potting mix (see above picture); these will be covered when we discuss cactus cultivation in detail. But first, an excellent way to get to know cacti better is to read about cacti in the wild. There are plenty of travelogues by cactus enthusiasts that you can read online.

Before 2013, I had already found PMag, PClav and GBald via a combination of selection and luck, and enjoyed some flowers too. But conceptually, my thinking was still faulty – the “desert plant” idea was still leading the way in my brain. Around 2013, a number of free C&S periodicals were started (I think it was due to easier registration of ISSN numbers in the EU), and it became much easier to regularly read publications that have material from basic to advanced.

20 This GBald produced its first flower in early June 2020.
21 Old GBald plants will produce offsets, this is an easy way to multiply your GBald collection.

I was struggling to *properly* piece together the puzzle of cactus cultivation in the tropics. In one of the 2013 periodicals (picture below), there was an article that finally pointed the way to a very significant piece of the puzzle. *The Stone Eaters*, the Xerophilia special issue also from 2013 (mentioned in an earlier footnote) validated those ideas[22]. The two do not talk about exactly the same thing, but they both point in the same general direction. This is the nutrition bit that we will cover in the next chapter. Appropriate nutrition leads to strong and healthy plants and more reliable production of flowers. For example, I have never noticed very wooly areoles on GBalds before about late 2019, so I am probably doing something right.

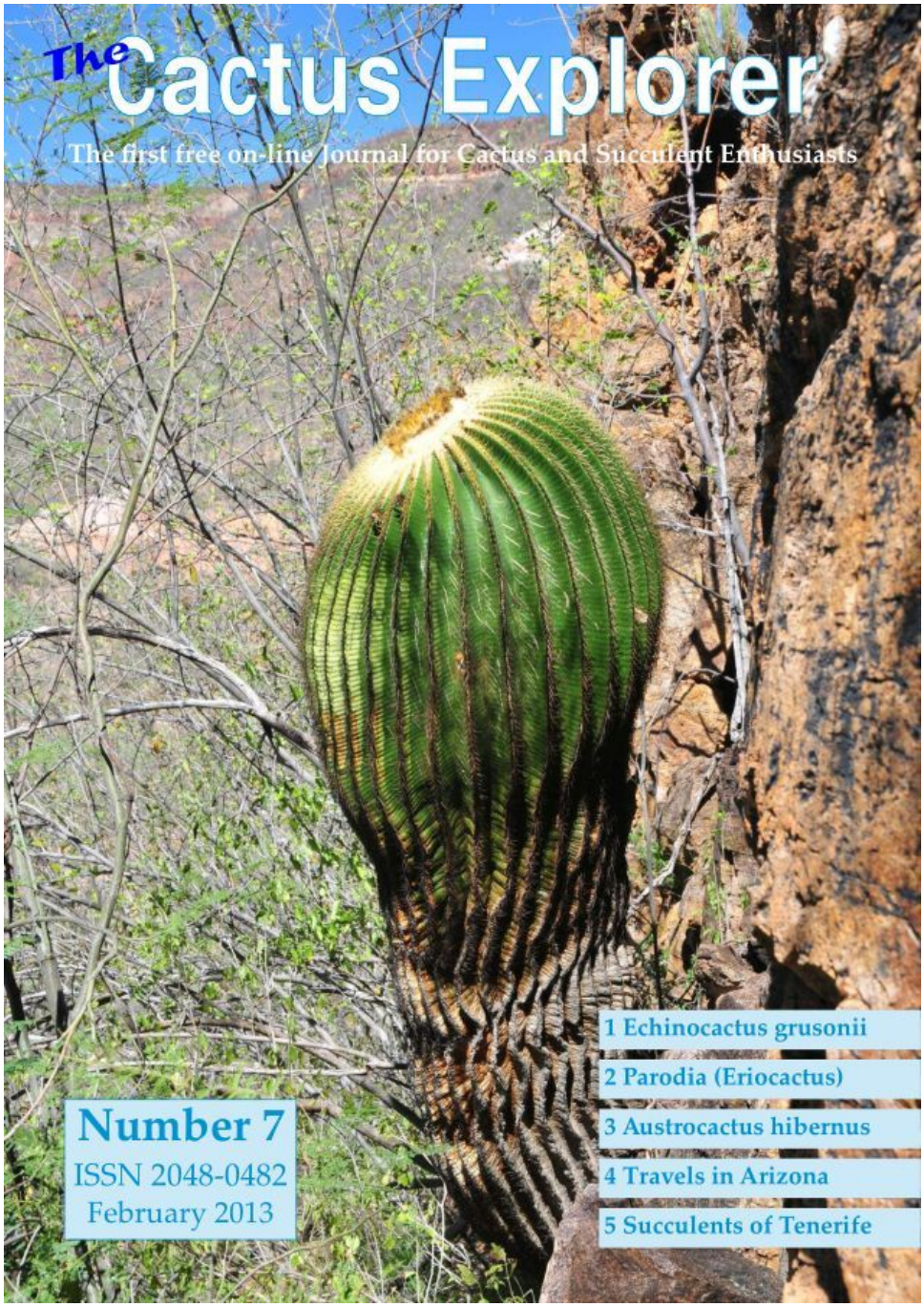
Acta Succulenta 1(1) 2013 (cover screenshot). I found the key to the puzzle in here.

Speaking of puzzles, one can think of cactus cultivation in the urban tropics as a puzzle of many pieces. Species selection is one piece of the puzzle. Other puzzle pieces include: adjusting to slow growth, adapting cultivation methods to local conditions, adjusting soil mixes for pots, nutrition, watering strategies[23] and bug control. The objective is to really *understand* things; while it's easy to follow ready-made recipes, understanding takes knowledge, time and effort.

The point is this: An important part of our journey to become better cactus growers is to understand their natural habitat and behaviour. This is also roughly the view of Dag Panco at the conclusion of *The Stone Eaters*. There is a limit to what you can absorb in the form of words, so it is a good idea to supplement the words with pictures. In the Internet Age, you can easily tour the natural habitats of cacti virtually, in the form of words and pictures. If you see where and how cacti grow in the wild, you will know them better.

22 I do not actually follow the recommendations in *The Stone Eaters* closely because my focus is on understanding the behaviour of cacti. Once you understand what is happening, you can then take your pick of valid solutions.

23 With a good soil mix, watering ceases to become a significant issue. I don't even water, I just spray them.



The Cactus Explorer Issue 7 February 2013 (cover screenshot). Based in UK, *The Cactus Explorer* has been publishing steadily since 2011. On this cover is a picture of an *Echinocactus grusonii* in Mexico. PClav clinging to cliffsides look almost exactly like this. There is an article discussing PClavs by Anceschi & Magli in this issue with many pictures of PClav clinging to cliffsides.

I think looking at pictures of cacti in habitat is healthier than looking at perfectly-grown showpiece specimens. It's okay if your plant is not a perfect green stem.

As of mid-2017, the following are the free cacti and succulents periodicals that I have read or followed. Not all of these have been publishing steadily, because high-quality material is not trivial to create[24]. Some are not in English, but the pictures are still very useful.

- *Acta Succulenta*: `http://www.acta-succulenta.eu/`
- *Cactus Explorer, The*: `http://www.cactusexplorers.org.uk/journal1.htm`
- *Echinocereus Online-Journal*: `http://www.echinocereus.eu/`
- *Schuetziana / Schützіana*: `http://www.schuetziana.org/`
- *Succulentopia*: `https://www.cactuspro.com/succulentopia/`
- *Xerophilia*: `http://xerophilia.ro/`

The Stone Eaters is a special 2013 edition of *Xerophilia*. I believe there are other such periodicals, journals or reading material that can be freely read, usually as PDF files, but I haven't tried doing a comprehensive search. For example, the Mauseth *et al.* book that was mentioned a while back, **A Cactus Odyssey**, is also an excellent travelogue that you can download and read.

Sometimes while doing all the reading, you may want to know the names of the plants on sale in your area so that you can read about how related plants live in their natural habitat – when we know their names, the stories become more meaningful. For urban growers in the tropics who are dependent on stocks of commodity cacti, we can use online shops that sell roughly the same stuff and have pictures with species names. Two that I found (as of late 2019) are:

- `https://cactusshop.com/` (owned by Altman Plants)
- `https://cactus-shop.com/` (possibly Ukrainian)

There is a limit to what you can learn by collecting and comparing cultivation recipes. If you want to go beyond following other people's recipes or recommendations, the starting point is to learn all about cacti in their natural habitat.

A Cactus is Sort of a Modern-Day Bonsai

By now, it should be clear to you that a cactus plant is not like a regular houseplant. If you treat them like no-fuss houseplants for decorative purposes, you will probably miss out on the flowers. But if you think like a gardener, learn about them and provide the correct care, cactus plants can be very rewarding. I doubt zero-effort will be a very successful strategy; you will need to invest some time and effort in them. In fact, I often think of a cactus as sort of a modern-day bonsai.

Why are cacti like bonsai? Cactus plants grow slow; bonsai is not for people in a hurry either. Cactus plants are slow to change in size or shape; a bonsai is trimmed and trained to its pot year after year. Cactus plants are slow to give you big rewards unlike sunflowers, whose flowers can be enjoyed within 7 weeks after sowing the seeds. A bonsai specimen is a long-term project that is maintained and enjoyed year after year. And if you treat cacti and bonsai like houseplants or worse, commodity supermarket houseplants that can be disposed of on a whim, you won't get very far.

24 In a future edition, I will add a revised list, when some of these websites eventually start to disappear. I expect that most websites that disappear can still be found via the Internet Archive's Wayback Machine.

Three views of a *Gymnocalycium stenopleurum*. **Left**: Just bought, January 2002. **Middle**: New growth is a healthy dark green. Compare that to the pale green-brown older growth and the woody base further down. It is responding well to the stuff that was discussed in the *Acta Succulenta* article (March 2014). **Right**: Its first ever buds appeared in March 2017. Flowers are white.

Without understanding what you are doing, it is easy to lose interest in your cactus plants. For the first 11 years, the *Gymnocalycium* in the above picture was just hanging on. I thought "desert plants" should "tough it out" so they can "learn" to be hardy plants. Ha ha. In mid-2013 the nutrition change took place. It then took about 4 years to put out its first ever buds. This specimen flowered again in 2019. Unfortunately, although I see a lot of areoles with potential to produce buds[25], I think the evenly hot tropical weather does not give it that final push to make it flower. So like growing bonsai, patience is necessary, as is proper nutrition. GBalds, luckily, are much more willing to flower.

Have you seen bonsai specimens in urban gardens lately? In Klang Valley, Malaysia, bonsai sellers and bonsai growers are almost non-existent where I live. Modern culture has sped past and left the hobby of gardening eating dust. Many modern urban folks now prefer low-maintenance houseplants, and they also have more modern hobbies, such as reading and gaming on computer tablets.

If bonsai is an ancient art form, then growing cacti is like a last generation craze. Both are niche or specialized forms of gardening – cactus cultivation is a modern niche, while bonsai is an ancient niche. Both seem to be losing their lustre in modern, post-2000 culture. If you want to be a successful bonsai practitioner, you should expect to apply yourself to the task for a number of years. Serious bonsai practitioners would have invested a lot of time and effort.

If you want to grow rewarding cactus specimens in a tropical climate, it turns out that caring for them isn't all that time-consuming. PMag, PClav and GBald are low-maintenance species and their needs are simple. Unlike bonsai, one does not spend hours pruning and shaping specimens. Care means spraying them with fortified water[26] once or twice a week. Water sprays keeps spider mites away. Risk of scale insect attack is highest with GBalds, so I keep a closer eye on them. Luckily, scale insect attacks do not happen all the time. Repotting is not done often. To be sure, the level of care is not perfect and the plants are not perfect, but things are manageable over many years. *This is not about perfection* or about growing plants to compete in plant exhibitions. Always remember, cactus plants in the wild do not look perfect.

25 Wooly areoles, often visibly elongated, probably that sign of mature phase, again. This wooly areole thing seems to be common among South American cacti. Some actually look like they contain buds.

26 This is roughly equivalent to foliar feeding or fertigation. This will be discussed in detail later.

Five GBalds in bloom, posed, February 2020. Once you know what to do, cactus cultivation isn't very time-consuming. These days I spend more time taking pictures of cacti compared to the time taken doing proper cultivation work. The pictures allow me to trace their behaviour over time. Note that these are all from offsets or cuttings; the original GBalds have long since died or got cut up post-shrinking.

Because of its weak lower part, the grafted GBald (the upper right GBald) fell off from its bottom stock MGeo in late January 2020. I am now trying to grow it as a normal plant. It's rather big compared to the other GBalds. Scarring on some plants is due to manual removal of scale insects; the plants were attacked in late 2019. In the background are a few MGeos and the disposable burger clamshell container with *Haworthia limifolia* and PClav seedlings inside.

If you understand your plants and know what you are doing, you will have the patience to stick to your cultivation regime. **Left**: This is a group of three GBalds of roughly the same size, a few months after dormancy (May 2018). New growth is in the centre. Old growth I think is suberized[27], meaning those parts turned corky. Nothing to lose sleep over. At lower left is the same GBald pictured on page 20 as a small rooted offset – 20 months earlier. **Right**: If you know what's going on, it's no crisis. Relax and just let them grow out again. After less than two years (February 2020), two have flowered. The only crisis was that scale attack in late 2019. In terms of general care, pretty much all they got were fortified water sprays.

If you understand what you are doing, cactus cultivation in the tropics (the practical way) will take less time than bonsai cultivation. But you do need to maintain a sustained level of interest in your collection so that they get at least some attention every week. Unlike leafy bonsai specimens, neglect probably won't kill your cactus plants, but they will be in poor shape and your interest will falter.

If your plants look like a disaster zone after a bout of dormancy (above picture), you will not be in despair if you understand these plants and know how they live. Just get them back up on their feet, be patient, and you may well be rewarded. PMag and PClav do not do the shrinking thing, but they are less prolific when it comes to flowers.

For modern urban folks, sustaining your interest in slow-growing plants is no small matter. For the younger set, they have grown up among smart phones and computer tablets (the iPhone was introduced in 2007.) A person can instantly get information via phone apps. They can buy things online – effortlessly. Games on your phone or tablet constantly reward players with sights, sounds, and 'achievements' to keep them interested (or hooked.) This is the age of *instant feedback, instant results*. This kind of modern lifestyle is not a good match to cacti cultivation.

So keep an eye on your brain – make sure your smart phone habits do not usurp your gardening habits. Spraying fortified water once or twice a week sounds easy, but effort must be sustained. This is a mental adjustment that many of us urban folks have to make. ♦

27 Unclear if it's normal dormancy behaviour, because it may also have been a reaction to something.

Version Information

This is the June 2021 Edition of this document.

Every released PDF can be found at: `https://www.mysmallcacti.net/`

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Colophon

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