Issue 7 | July - August 2018
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iHerp Australia

ALL THAT GLITTERS IS NOT GOLD.

The Golden Tiger Snake of Tasmania.

SNAKES THAT SHIVER.

Incubating pythons turn up the heat!

IT'S NOT EASY BEING GREEN.

Interesting observations derived from captive Green Tree Pythons.

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Marble Children's Python

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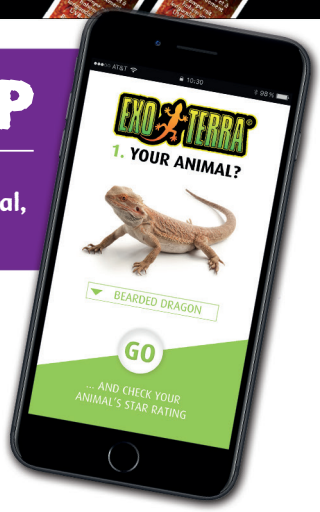

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The 'Wrangler' Writes...

Time has flown, and iHerp Australia is celebrating its first birthday with another issue packed with features that, as always, is free to download. So take some time out from winter maintenance to check out all our great articles.

We've been on at Simon Fearn for a long time to write something about the fabled 'Golden' Tiger Snakes of Tasmania. Finally he has come through with the goods on an incredible naturally-occurring morph that really doesn't look like it belongs in a cooler climate. Speaking of morphs, we were a little sceptical when Dave Evans declared the 'marble' Children's Python to be one of the most exciting animals in the hobby, but his snakes are out of this world – take a look at the photos!

We also have a couple of great field-herping articles in this issue. One from none other than the legendary Rom Whitaker, and the other from Nick Gale, who once again proves that you don't have to travel too far from the suburbs to find some amazing reptiles. Plus Kit Prendergast explains why pythons are 'hot' and Gerrut Norval and Michael Gardner, from Flinders University, have contributed a piece on the dangers of long distance travel for lizards.

Now, for all those who like naturalistic terrariums, Ben Dessen is along to get you started in the brand new age of 'Bioactive Systems' – a trend that is sweeping the hobby overseas and rapidly gaining traction here in Australia. And, being winter, we have a special article on brumation – what it means and what to do about it in captivity.

It's been a heck of a year. iHerp Australia was conceived as a free resource that could be useful to anyone interested in reptiles, and as a platform, particularly for up and coming authors. We're steadily reaching more and more people out there, but if you like the magazine, please tell your friends! And don't forget, if there's something you would like to see in the magazine, drop us a line.

Lastly, for those who like to hold a hard copy in their hands, we have a special limited offer currently available – check out the store in our website.

Happy Herping!

John McGrath

iHerp Australia

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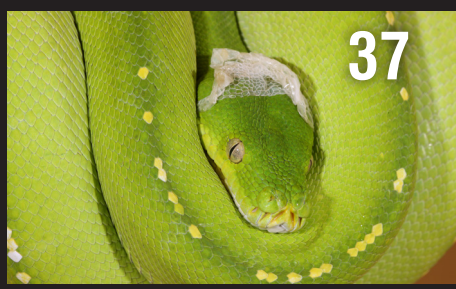

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On the cover: Eastern Brown Snake (*Pseudonaja textilis*). Image by Janne Torkkola. Janne's article on snake translocations will appear in our September issue.

All that glitters is not GOLD.

The golden Tiger Snake of Tasmania.

***Simon Fearn** reveals that there is real gold in 'them thar hills', but warns potential prospectors to be wary of forgeries.*

Tasmania's cool and highly variable climate has undoubtedly played a significant role in selection for dorsal colouration in Tiger Snakes (*Notechis scutatus)*.These large snakes thrive under conditions which must be close to the lower limits of their thermal tolerances, particularly in relation to reproduction. There is therefore a general overall tendency for melanism throughout Tasmania, but especially in cool, high rainfall areas of the west and southwest, as well as the extensive central plateau where it can snow at any time of the year.

Banding on Tasmanian specimens is also generally less defined than many mainland Tiger Snakes, and band width is typically reduced to between half and one and a half scales. A significant proportion of predominantly black specimens display banding that ranges from bold contrasts of brown, orange, yellow or white to barely discernible cross bands that can only be perceived in strong sunlight. On many melanotic specimens banding is reduced to yellow or white edging on the first few rows of dorsolateral scales. Completely melanotic Tiger

Snakes can occur anywhere in Tasmania, and although in the minority, are more common in the Central Highlands. In warmer, low-lying and particularly coastal habitats in eastern Tasmania a bewildering array of colour variations can be encountered; from rich yellows to shades of tan, brown, grey, silver and some that appear almost greenish under appropriate lighting. The vast majority of these animals display darker cross banding, but in the forests of the Great Western Tiers, in the foothills of the central plateau, the author has

***Left:** wild yellow Tiger Snake exhibiting prominent banding from Railton.*
Photo by M. Wapstra.

***Above right:** 'washed out' Tiger Snakes raised without UV light. These are from the late Phillip Goss's collection. The lower snake would be predominately greyish-black with indistinct yellow bands if raised outdoors.*
Photo by S. Fearn.

***Right:** this large Tiger Snake has been raised indoors and would be horribly sunburnt if put outdoors in summer.*
Photo by S. Fearn.

observed some light brown specimens with darker cross banding reduced to splotches, speckles and even longitudinal stripes either side of the back bone, very reminiscent of some mainland Carpet Pythons. In fact, in the early days of settlement in Tasmania, usage of the term 'Tiger Snake' was confined to obviously-banded specimens, with paler animals being universally referred to as 'Carpet Snakes'.

There would appear to be complex and poorly-understood interactions between localised temperature regimes, vegetation structure and substrate, as well as predator assemblages that combine to produce the almost endless variation that can be observed in Tasmania. In warmer habitats, paler colours may not only aid in effective camouflage on sandy substrates strewn with fallen leaves, but they may also allow snakes to forage in the open for longer than melanotic specimens without over-heating in the summer sun. The predominance of melanism among the many island populations exhibiting warmer, frost-free climates is possibly a result of intense selection for animals that can bask very efficiently, even on over-cast days, during a very short and saturating annual feeding period based on the synchronised hatching and growth of seabird chicks.

Ventral colouration is less variable and is mostly white, cream or yellow, fading to greyish towards the vent. Ventral colour infrequently extends under the head on specimens from the Tasmanian mainland but

'In the early days of settlement in Tasmania, paler specimens were universally referred to as 'Carpet Snakes'!'

Left: *a pretty little gravid female from Four Springs Lake, Selbourne. Paler coloured snakes like this are common in parts of Tasmania and typically give birth to yellowish neonates. Photo by S. Fearn.*

Above right: *neonates like this are common in Tasmania but often go much darker as they age in the wild. Kept indoors without UV light this snake will become a more intense gold. Photo by S. Fearn.*

Below right: *a genuine wild golden tiger from the foothills of the Great Western Tiers behind Deloraine in northern Tasmania. Photo by B. Munday.*

more commonly so on specimens from offshore islands. Solid-coloured tan to brown snakes with no banding whatsoever and on which the ventral colour extends upwards onto the first few rows of dorsal scales are rare on the Tasmanian mainland but common on some Bass Strait islands - Chappell Island being one of the best known examples. Melanotic specimens throughout the Tasmanian region have also been recorded with all-black ventral scales.

The extensive colour range, and sometimes prodigious proportions, of Tiger Snakes from the Tasmanian region has made them popular with hobbyists for generations. One of the most sought-after of all these variations is the almost mythical 'golden tiger'.

Genuine, wild golden tigers are relatively rare, and most of the specimens I have seen have come from the forested eastern foothills of the Great Western Tiers in the northern part of the state. I vividly remember the first golden tiger I captured because it was also the first wild snake that I tailed. I was looking for Tiger Snakes late one summer afternoon at Liffey in the Great Western Tiers and while working my way along a creek line adjacent to a paddock I spied a magnificent 1.5m golden snake coiled on top of a pile of logs bull-dozed into the creek gully. The snake had spotted me and was starting to move off, so I had to think quickly before it reached the safety of a maze of logs and blackberries. I had only just started interacting with venomous snakes in the wild and had never tailed a wild elapid before, but I had no choice other than to fling aside my jiggers, scramble up on to the log pile and pick the snake up. Quite rightfully, the snake took offence at this injustice and did its best to bite me. A little horrified at the predicament I had gotten myself into, and not being well balanced on top of the log pile, I flung the snake

as far as I could into the paddock, climbed down off the logs, retrieved a jigger and pinned the animal while it was still trying to figure out what had just happened. This particular snake lived for many years in captivity and was a crowd pleaser at talks and demonstrations.

Most wild tiger snakes in Tasmania that are predominately yellow or gold in colouration nevertheless retain a range of other darker markings (usually silver/grey) such as bands and/or splotches and spots. I have only seen two solid-yellow specimens. One was a headless corpse (again from Liffey) delivered to me by a farmer who thought he had discovered a new species of snake, and the other was on Chappell Island of all places. While very yellow wild snakes are quite rare, captive-bred and raised 'fakes' can easily be produced in numbers. Pale brown/tan to yellowish Tiger Snakes with darker bands are common in many warmer, low-lying parts of Tasmania, and if these animals are mated in captivity the resulting

‘I have only seen two solid-yellow specimens - one was delivered by a farmer who thought he had discovered a new species.’

clutches always have a selection of yellowish to orange-coloured neonates. If raised indoors without natural levels of ultraviolet (UV) light, these snakes become progressively paler and more yellowish, and the darker markings with higher melanin levels fade and become more indistinct over time. While some of these snakes can look spectacular I would not class them as natural, and they represent a potentially-unpleasant trap for inexperienced keepers. If these snakes are moved into outdoor enclosures (common practice amongst Tasmanian keepers) they can get horribly sunburnt in a single day in mid-summer.

This may seem very odd to some that a snake could get sunburnt, but if a captive-raised snake whose skin and scales have never been exposed to UV light is suddenly exposed to high levels, the results can be catastrophic. Sunburnt pale snakes can turn melanotic within a very short time as the skin tries to adapt to UV. I have seen this phenomenon on many occasions and always urge keepers to exercise extreme caution when introducing indoor-raised snakes to outdoor enclosures. I always do this in August when day lengths are still relatively short, mid-day temperatures comparatively low and solar angle is low in the sky. This gives the snakes' skin a chance to adjust gradually and burns are avoided. In this way, snakes that were always going to be pale will remain so and those that would naturally have darkened up do so in a natural manner. Sunburnt snakes typically display a rather ugly and unnatural-looking solid dark grey to black streak which runs the entire length of the body, particularly along the spine which is exposed to the most direct sunlight. If you are offered a golden tiger, it is a good idea to learn as much as you can about its parentage and captive history to determine if you have the genuine article or simply 'fool's gold'!

Further Reading

For more pictures of colour and other variations in Tasmanian tiger snakes see:

Fearn, S. 1993. The tiger snake *Notechis scutatus* (Serpentes: Elapidae) in Tasmania. *Herpetofauna* 1988: 3 -4.

Fearn, S. 2011. A rich and varied canvas: Scale variations and scarring on Tasmanian tiger snakes *Notechis scutatus* (Serpentes: Elapidae). *The Tasmanian Naturalist* 136: 2-18.

Fearn, S. 2014. *Snakes of Tasmania*. Queen Victoria Museum and Art Gallery. Launceston.

Below: *the pale snake was born to a wild-caught female from Bruny Island, southern Tasmania. I had to be very careful when introducing this specimen to natural sunlight outside to avoid sunburn. Photo by S. Fearn.*

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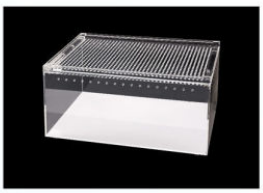

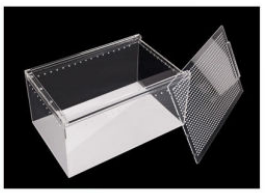

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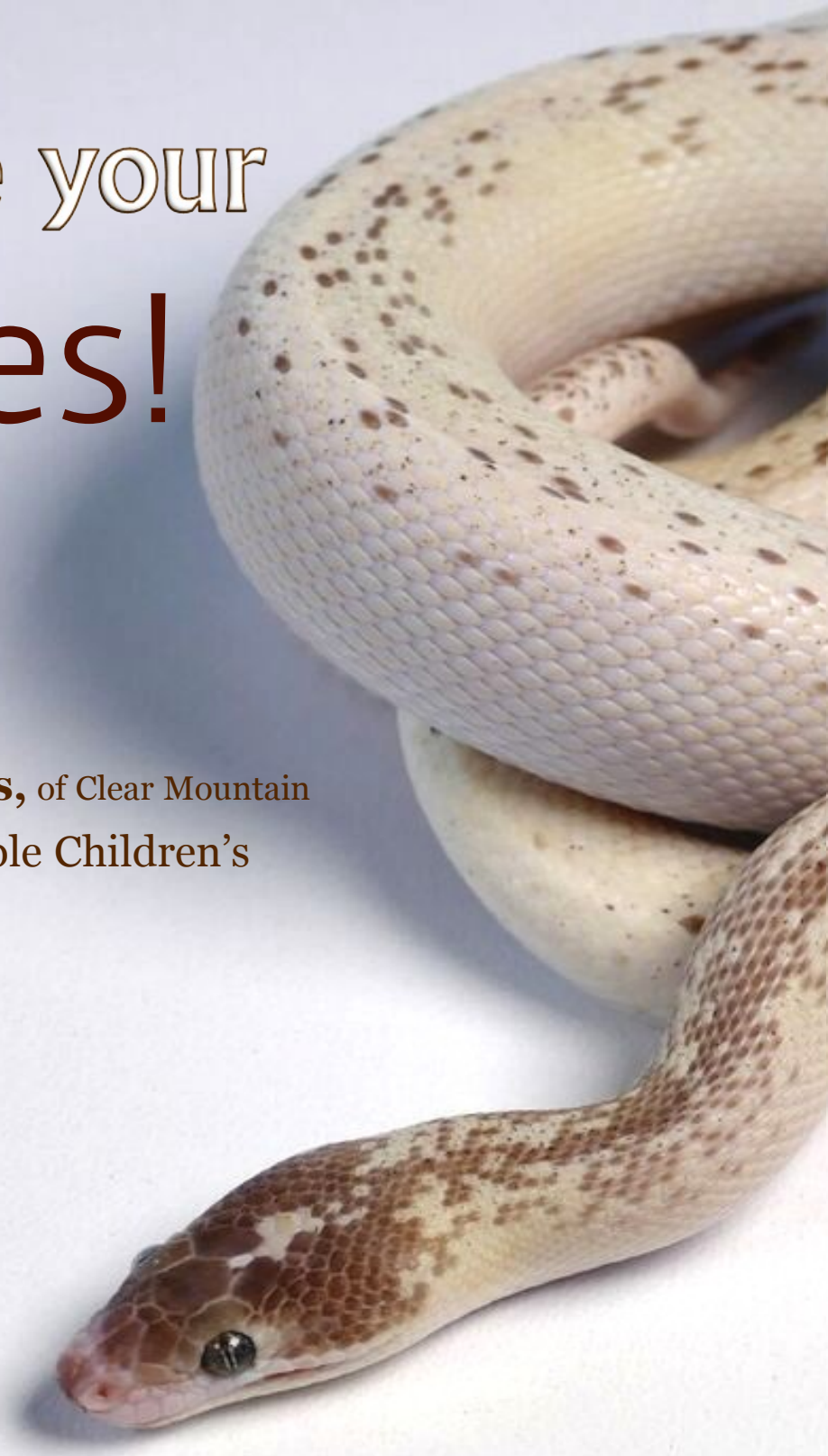


Renowned breeder **Dave Evans,** of Clear Mountain Reptiles, is excited about the Marble Children's Python morph

White Marble Children's Python.
All images by Dave Evans.

Children's Pythons (*Antaresia childreni*) are relatively small snakes, with most adults reaching about 70-80cm and a maximum size of around one metre. They are found through the northern parts of Western Australia, the Northern Territory and Queensland (along the western side of Cape York Peninsula). Their distribution borders that of the Stimson's Python (*A. stimsoni*) in western and central regions, and the Spotted Python (*A. maculosa*) in the east.

When they hatch, Children's Pythons have a creamy-brown base colour with areas of darker brown patterning running the entire length of their bodies. As they grow the base colour will generally darken, making the markings less obvious; some adults have an almost patternless appearance.

Hatchlings can sometimes be a bit tricky to get feeding, but once they will take rodents they generally don't look back and as adults will normally accept mice, rats or quail whenever food is offered. They are hardy snakes once established and will thrive in captivity when provided with the correct conditions.

There are several mutations that have popped up in Children's Pythons over the years, but for this article I will be focussing on the Marble (or Marbled) morph that, in my opinion, is one of the most visually compelling mutations to have appeared in the reptile hobby in Australia.

The founding animal for this morph was a wild-caught specimen from the Northern Territory which, after being swapped for some other animals, ended up in Simon Stone's collection at Southern Cross Reptiles. This female was named 'Holy Grail' by Simon, and was bred to a normal male to produce some 100% hets. Then het-to-het pairings and visual-to-het pairings were used to produce more Marbles. At first it was thought that the hets may carry a visual marker, as they all had quite a cryptic, 'granite-like' pattern, but this was later disproven. Just as Simon was getting to the point of having enough animals to start breeding them to release into the hobby, he decided to retire, so the entire project was offered up for sale. I spoke to him at the time, and from memory there were approximately 80 animals in the group. Simon said he hoped that the buyer would keep the whole assemblage intact through to the following breeding season to really establish the project, particularly since the majority of the animals were possible hets or very young Marbles. However, the person who eventually ended up buying the animals didn't have the same idea, and sold off a few small groups to others in the hobby. That is how I acquired my original animals. Unfortunately, upon arrival several of the snakes were a lot smaller than described, and I also later discovered that a number were the wrong sex, which was disappointing, but these things happen and I still consider myself lucky to have been working with this morph for several years now.

'When Marbles first hatch they are light pink, with distinctive blue eyes.'

When Marbles first hatch they are a uniform light pink colour, with areas of brown and occasionally a wild-type pattern on the top of the head; they also possess blue eyes which makes them extremely distinctive. After a few sheds the base colour will generally begin to change to a more creamy yellow, and you will often see a few random individual scales start to darken. Occasional specimens will have areas of white coming up the sides from the belly - similar to how a pied animal can look - or almost the exact opposite, with random blobs or patches of dark scales clustered together on the body. As the animals continue to grow and shed the base colour will continue to intensify, becoming a rich yellow, and along the body more and more flecking will appear. The flecking can vary in colour from a very light brown through to jet black.

Although the amount of flecking will always increase over time, it is also very variable. Within a few sheds, you can tell that some animals will end up very heavily flecked, and by the age of 6-8 months may be almost entirely covered. I know some people have said that they cannot see the appeal of

Left: *dark Marble Children's Python.*
Above: *T+ albino Marble.*
Below: *hatchling normal Marble with white Marble.*

‘One of the most exciting mutations to have appeared in the reptile hobby.’

Adult orange T+ Marble, dark T+ Marble and white Marble.

White Marble Children's Python.

these very heavily-flecked specimens, as they think they look much like a normal Children's Python, but in the flesh they are something entirely different. They retain a very thin strip of the base colour that doesn't seem to get fully covered, so as you come up from the crisp, white belly you get a very thin line of the yellowy base colour coming through and then the very dark colouration which dominates the body, giving them a very unique appearance. As these animals age the flecking changes from dark brown to jet black, imparting an almost hypermelanistic look to most of the body.

At the opposite end of the spectrum, you can also get some very light Marbles, which in my opinion are some of the most stunning animals around. These can be hard to pick at an early age, as even hatchlings that are still quite pale at six months old can quickly change within a couple of sheds, with a lot of dark colouration mingling with their base colour. It is more a case of whittling down a clutch by progressively excluding animals which *won't* end up extremely pale, and then working with the palest ones to produce the next generation. It does seem that this gene can be (loosely) line bred to a certain extent for particular appearances, but a lot of variation can still pop up within a single clutch.

'I wasn't entirely sure what it would look like, but eventually after 55 eggs I got what I was after.'

The first year I bred with the Marbles I was able to get my T+ albino male over my female Marble and produce some nice double-het animals. After growing these up for a couple of years I was then able to pair them back to each other with the goal of producing a double-visual specimen. With a one in 16 chance of a double recessive combination, I knew the odds were always going to be against me, especially given the small clutch size of young *Antaresia*. As the season advanced and clutches started to hatch, I began to feel as though I wasn't going to be lucky, but eventually after 55 eggs I got what I was after! I wasn't entirely sure what the double-visual would look like but had expressed the opinion to a few friends that I thought it might be an orange animal, and turns out my guess was right. It

looked slightly different straight out of the egg, with more of an orangey tinge than the pink of a normal hatchy, but after its first shed the colour really popped and the bright orange worm with blood-red pupils was quite a sight to see.

Having now produced a few T+ Marbles, I have seen the variation that appears in normal Marbles flow into the double-visual animals as well. They can vary from a deep, rich orange base colour to a very light and bright orange, and the flecking can vary from chocolate brown to a light caramel colour. With a bit of experience it is very easy to pick them straight from the egg. The orange colour together with the pale head (where the dark pattern sometimes occurs on normal Marbles) are th strongest indicators.

I honestly believe that the Marble gene is the most interesting and exciting gene to work with at present in the Australian reptile hobby. When discussing these animals with people I feel that every statement could be premised with, 'In general...', as there does not yet appear to be a true understanding of what this gene is actually doing. It baffles me as to how a brown Children's Python can turn into a pink hatchling, which then changes to anything from a yellow to white animal with random amounts of flecking appearing over its lifetime. Most mutations are fairly clear-cut in their influence on an animal's appearance: albino means no melanin is expressed; axanthic results in reduced red or yellow pigment; while pied specimens have areas devoid of pigment. However, the Marble gene seems to be doing a number of things at once, as it affects both the colour and pattern of the animal, with changes continuing throughout its life. I think that as time passes and with more breeding there will be some truly weird and wonderful Marbles produced.

Follow Dave at: https://www.facebook.com/clearmountainreptiles/

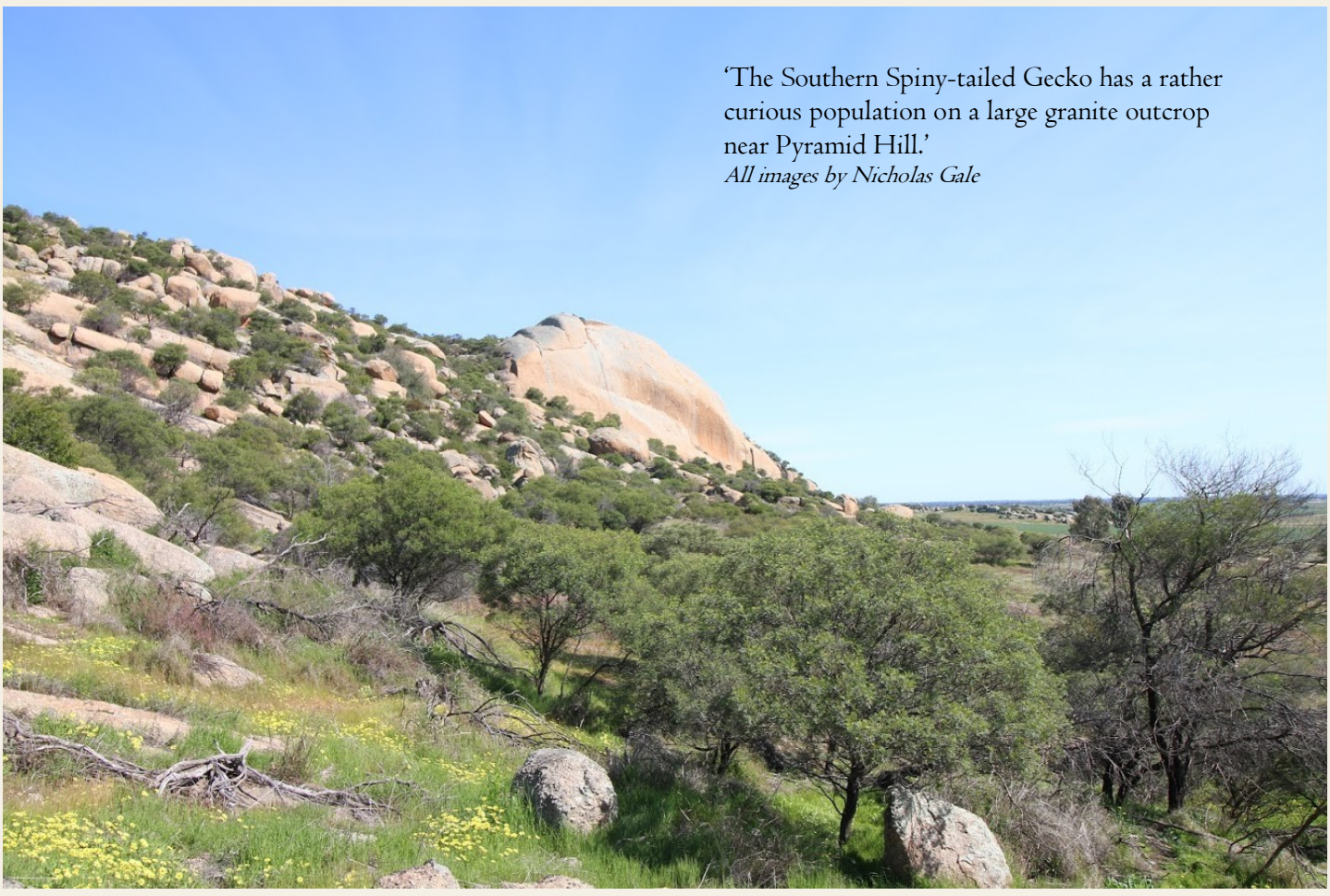
The Gecko on the Hill, and a 'Snake' in the Grass.

***Nicholas Gale** is at it again, demonstrating that you don't have to venture too far from suburbia in this country to find some amazing herps.*

Recently, my mate Dan Mangano and I headed up to north-central Victoria for a day trip, in an attempt to locate some Mallee species that have unusual distributions that encroach into central Victoria. Our main target would be the Southern Spiny-tailed Gecko (*Strophurus intermedius*), a species that is quite common in the Mallee region, but that also has a rather curious population on a large granite outcrop near Pyramid Hill, 200km from any real, arid, Mallee-like habitat. To a lesser extent, I also wanted to see a Curl Snake (*Suta suta*), a small elapid species that exists in some grasslands around central and northern Victoria. I heaved myself out of bed on a sunny Sunday morning, observing with some satisfaction that there was not a cloud was in the sky. Although the temperature would not exceed 20 degrees Celsius for the whole day, the sun was enough to bring out the species we wanted to see.

We jumped into the car and drove north for about three hours, only stopping to buy snacks at Rochester. The new version of the chocolate 'Yowie' proved to be very disappointing, and I should have listened to Dan's warning and not bought one! After about half an hour of driving past canola plantations, we began cruising through some cypress woodland. How strange. I lost focus on the road, and began dreaming of finding my first spiny-tailed gecko. Not a second later, Dan slammed on the brakes, pulled the car to the side of the gravel road and jumped out in a sprint. I fell out of the passenger's-side door, 'trying desperately to spur my legs into action and grab my pack simultaneously. It turned out that Dan had spotted a nice Eastern Bearded Dragon (*Pogona barbata*) trying to cross the road. After a quick photo session we let him on his way. A quick check of Google Maps revealed that we were in the midst of Terrick Terrick National Park, which explained the cypress woodland.

We continued on and began to near our destination, with an increase of cars becoming apparent on the road. On the top of a hill we spotted another bearded dragon; this one being an



'The Southern Spiny-tailed Gecko has a rather curious population on a large granite outcrop near Pyramid Hill.'
All images by Nicholas Gale

'On the top of a hill we spotted another bearded dragon;
this one being an ABSOLUTE MONSTER.'

absolute monster. We moved him out of harm's way, amazed that he hadn't been hit by the barrage of traffic that was in front of us. After some wrong turns, courtesy of Dan's phone, we found ourselves in a small car park at the base of an enormous granite hill. No real path was apparent, so we began to scale rocks in order to reach the top, which was no easy feat.

Tree Skinks (*Egernia striolata*) were abundant, and became the most common herp of the trip. Whilst I was photographing a juvenile, Dan witnessed two males fighting. I regret not dropping my camera to go see what was happening, but I was happy with how the photos turned out. The adults seemed to be very prolific, but were usually heard instead of seen - darting into rock crevices and bushes when approached. We managed to get pretty close to some adults, but it proved extremely difficult to get any decent pictures of them. Dan pointed up into a tree, where he had spotted a very young Tree Skink resting in the fork of a branch. As we climbed higher and higher, I carefully scanned the acacia trees in the search for spiny-tailed geckos. After a while I got slightly ahead of Dan, eventually losing sight of him. Along with the Tree Skinks, South-eastern Sliders (*Lerista bougainvillii*) and Marbled Geckos (*Christinus marmoratus*) appeared to be common in this habitat, but I photographed neither as both species are plentiful in Melbourne.

Finally, I made it onto a relatively flat area close to the summit, where I noticed a particularly appealing acacia tree. Sure enough, I had soon found a Southern Spiny-tailed Gecko! The lizard had a minuscule, regenerated tail that had been recently lost, but I was still over the moon! I assumed that it had most likely been the victim of a Tree Skink, as no small elapids had been recorded on the mountain itself. Dan was nowhere to be seen, so I began screaming at the top of my lungs, "Dan, I found a 'stroph'!"

After five minutes of constant yelling I began to get worried. Had Dan been eaten alive by a mob of hungry Tree Skinks? Attacked by a dropbear? Horrible but unlikely scenarios swirled around in my head, but soon Dan came into view at the bottom of the clearing. He told me that he hadn't heard anything at all; my voice was likely lost in the wind. I set up my camera gear and began to take photos while Dan wandered off to explore the very summit. As I was finishing up he returned with the news that he had seen more Tree Skinks and a possible Cunningham's Skink (*Egernia cunninghami*). I searched the tree that I found the tailless gecko under with no further success, so we decided to head off back down the mountain. Before we did though, we took in the 360 degree view of the area around us. Yellow canola crops completely blanketed paddocks, in stark contrast with the surrounding green and brown farmland.

"Dan, I found a 'stroph'!" The lizard had a miniscule, regenerated tail, but I was still OVER THE MOON.

Southern Spiny-tailed Gecko (*Strophurus intermedius*).

It was a scramble down the hill, and we only found more small skinks and Marbled Geckos on the descent. At last we came to an open grassy plain - perfect habitat for Shinglebacks. However, no large reptiles were observed in this area, and soon enough we made it back to Dan's car. Not long afterwards, on the drive back, we spied a long, brown blob sitting in the middle of the road. Another car was barrelling toward us, but luckily it swerved out of the way of the slow-moving lizard. We jumped out to find a very clean adult Shingleback (*Tiliqua rugosa*), which proceeded to poop in an almost projectile manner all over Dan! We checked the animal for ticks and let it go after some quick photos. Dan let me take charge of the wheel, and soon he was spotting bearded dragons left and right as we cruised back through Terrick Terrick.

Before long we reached a small grassland in central Victoria, and began searching for Curl Snakes and Olive Legless Lizards (*Delma inornata*). We soon found a baby Eastern Blue-tongue (*Tiliqua scincoides*) along with many Boulenger's and Common Dwarf Skinks (*Morethia boulengeri* and *Menetia greyii*, respectively) which were sheltering under densely-packed tussock mats. The grassland would have been close to bare only a few months prior, as instead of burning off, the managers had chosen to use sheep to prevent the grasses from overgrowing. I carefully looked under a piece of cover to see a dwarf skink dart away, and just as I was about to replace it, my jaw hit the ground. A juvenile Striped Legless Lizard (*Delma impar*) - a federally-listed endangered species! I called Dan over, and we gazed at the beautiful little reptile. I managed to get some pictures of it licking its eye, a characteristic trait of geckos and pygopods alike.

The Striped Legless Lizard is sometimes confused for a juvenile brown snake. The decline of this species has coincided with destruction of its grassland habitat for agricultural and urban development, and remaining populations are considered small and isolated. In fact, 99% of south-east Australia's grasslands have been destroyed since European settlement. In 2015-2016, the species' sole remaining habitat in Canberra, opposite Exhibition Park, was turned into a caravan park. Thankfully, in this instance, conservation group Bush Heritage Australia intervened to save the estimated population of 200 Striped Legless Lizards. Around 800 roof tiles were used as 'heat bait' to attract the lizards, which were relocated to a reserve 75km away.

We left the lizard to go about its business, not at all perturbed that we missed out on Curl Snakes and Olive Legless Lizards. Another road close by held records of both species, but it was heart-breaking to see the roadside absolutely destroyed by farming machinery, and some tin that I had placed back over a year ago nowhere to be seen. However, we powered on, and after I almost got Dan's Commodore bogged in mud, we cruised through Kamarooka in the hope of seeing some basking herps, to no avail. The setting sun streaming through the trees on the side of the road still proved to be a magical sight. As with the end of every herp trip, we had an obligatory stop at the Eaglehawk McDonald's, filling our stomachs after a day I will not soon forget anytime soon.

Eastern Bearded Dragon (*Pogona barbata*).

Striped Legless Lizard
(*Delma impar*).

*Conservationist and wildlife advocate **Ben Dessen** is Reptiles Department Manager at Kellyville Pets and is passionate about educating newcomers to the reptile hobby. In this issue he ventures into the 'brave new world' of bioactive systems....*

An introduction to Bioactive Systems.

The reptile hobby in Australia is going through an exciting new phase. With the next generation of reptile keepers, we are witnessing a fresh approach and a new set of values surrounding the care and maintenance of reptiles and amphibians. A shift towards providing reptiles with natural captive environments that replicate wild habitats and conditions is well and truly underway. Australian herpers are following in the footsteps of many international keepers and going bioactive!

Bioactive systems (sometimes written as bio-active) seek to recreate an animal's natural environment as closely as possible through the use of live plants and organic substrates with living invertebrate decomposers, along with appropriate temperatures, lighting and humidity levels for the species being housed. By replicating an animal's wild living conditions, not only can their health and wellbeing be optimised, but an aesthetically pleasing and attractive display can also be achieved. Bioactive systems are a modern approach to reptile and amphibian husbandry, as we evolve beyond more traditional methods such as newspaper substrates, toilet-roll hides and dark racking systems!

Type of System.

The first step in creating a bioactive system is to understand the needs of the species you wish to house. A good starting point is to research the specific husbandry requirements, natural living conditions and habits of the animal. Ask yourself a series of questions. Is it a tropical, arid, temperate or alpine species? Is the animal arboreal, terrestrial, fossorial or aquatic/semi-aquatic? Can the animal be found basking out in the open, or does it prefer plenty of

cover? These are all important factors to consider in your enclosure design and will ultimately determine the type of substrate, plant species and other furnishings (such as logs and branches), as well as temperature and humidity levels of the system.

Enclosure.

To achieve a bioactive system, purpose-built glass reptile enclosures are generally the most suitable option as they have easy front access, adequate built-in ventilation and come in a range of shapes and sizes suited to terrestrial, arboreal and semi-aquatic species. Glass reptile enclosures are usually waterproof to a certain level and are good at retaining humidity and moisture. Re-appropriated aquariums can also be converted to bioactive systems, however lack of front access can be problematic, making it difficult to maintain and service the system solely from the top. The size and configuration of the enclosure will be dependent on the species-specific requirements, as well as the number of animals being housed.

Substrate and Drainage.

The success of a bioactive system is dependent on its foundations - the substrate layer. The substrate in these systems will become a living, breathing entity of its own, supporting organisms capable of breaking down the waste of any reptile or amphibian inhabitants. In a fully thriving bioactive system, one rarely has to remove waste or faeces from the enclosure, as these invertebrates should do much of the cleaning for you, just as it would take place in the wild. It's amazing to watch reptile or amphibian poo get completely broken down and disappear into the soil in as little as 24 hours!

First attempt at a Bioactive System!

1. *With drainage layer and mesh installed.*

2. *Note use of rocks as 'retaining wall' in LHS back corner.*

3. *Selecting the plants is the creative element!*

4. *Almost a year later. Without the framework of the enclosure being visible, this is reminiscent of a lush, natural tropical habitat! All images courtesy Ben Dessen.*

A drainage layer is essential to ensure the soil does not become waterlogged. Scoria, a gardening product made up of crushed volcanic rock, can be spread across the base of the enclosure to a depth of approximately 3-5cm. Other products such as hydro-rocks (clay balls) and egg crate can also be used to create the drainage layer. A thin layer of fine shade cloth or mesh can then be placed above the drainage material to prevent the substrate from mixing through, whilst still allowing water to drain from the soil. Some keepers install a tap and valve system so that excess water can be removed, rather than sitting in the base of the tank and becoming stagnant, however, this involves cutting a hole in the glass and siliconing in a tap. It is crucial not to over-water the system, as water build up in the soil will quickly kill off the plants.

All substrates used in a bioactive system must be completely organic, with no fertilisers, chemicals or water retention crystals. A good tropical soil mix can be made up from 80% organic potting mix and 20% coco peat. Arid substrate can be created using 50% sand, 40% organic potting mix and 10% coco peat. A thin layer of horticultural charcoal can be sprinkled between the drainage layer and substrate mix to assist in minimising bacterial build up and foul odours. The soil mix should be filled to a depth of at least 15-20cm, or even deeper, depending on which plant species are to be grown. Layers and mounds of soil can be created, using rocks and timber as 'retaining walls' and adding depth and detail to the enclosure layout. A layer of leaf litter can also be spread on the surface of the soil. Over time the soil will compact, and every 6-12 months a bio-revitaliser (organic nutrient mix) should be added to the substrate to ensure adequate nutrients are available to the plants.

Above and below: *construction of an arid bioactive set up for Smooth Knob-tailed Geckos.*

Living invertebrates known as 'custodians' or the 'clean up crew' should be added to the fresh sub-strate mix and left to begin colonising

the soil for at least one to two weeks before any reptiles or amphibians are added to the enclosure. During this colonisation stage, the invertebrates will need to be fed on a special custodian pellet, and they will also readily accept dead, crushed crickets and other feeder insects. Springtails, slaters, earthworms, mealworms and white worms can be used as soil custodians. Specialist reptile stores such as Kellyville Pets are now beginning to carry various invertebrates suitable for bioactive systems and the food products required to maintain them.

Lighting and Heating.

Live plants require bright, natural, full-spectrum white light in order to carry out photosynthesis. A lighting hood or reflector should be positioned on top of the enclosure and fitted with appropriate lights that will usually consist of either LED or compact E27 screw-in globes and come in a range of strengths and sizes. Ideally light output should be within the range of 6500-10,000K (or Kelvin, a measure of 'colour temperature') to stimulate good plant growth.

Depending on what animal species is being housed, a heat source as well as a UVB globe, or tube, will also need to be included on the enclosure. Heat sources must be controlled by a thermostat to regulate temperatures and all lights should be run on a timer for 10-12 hours per day so that both the plants and the resident animals have appropriate day and night cycles. Careful consideration must be given to the placement of basking spots and heat sources, as intense direct heat will cause many plants to dry out and die. Focussed, tight-beam globes that create a hot basking spot are generally more effective than wider-beam ceramic heat emitters.

Plant Selections.

Selecting the plants for a bioactive system is the creative element of the process. However, it is important that the right species and mix of plants is used, as some can be toxic to animals and others may not thrive in the conditions of the enclosure. When initially planted, foliage can be trained or directed to grow up rock walls or along branches in a desired direction. A number of plant groups and species suited to different environments are listed below, however, this provides a general guide and careful research should be undertaken before placing any plants inside an enclosure with an animal.

Tropical: bromeliads, ferns, *Calathea* spp., orchids, *Tillandsia* spp. ('air plants'), Climbing Fig (*Ficus pumila*), Peace Lily (*Spathiphyllum* spp.), *Begonia* spp., *Fittonia* spp., Pothos, *Philodendron* spp. and various species of moss.

Arid/Temperate: various succulents including *Sedum* spp., Pigface, *Echevria* spp. and *Crassula* spp.; *Tillandsia* spp.; small arid/native grasses such as *Festuca* spp., *Lomandra* spp.; Weeping Fig (*Ficus benjamina*).

Paludarium (half water/half land): *Cryptocoryne* spp., *Anubias* spp., Java Fern, *Hydrocotyle* spp., as well as many of the species suited to a tropical enclosure.

Plants must be carefully positioned inside the enclosure to ensure there is plenty of room for the animal(s) to move around. Remember, plants will also offer areas of cover for the inhabitants to retreat to as well as a natural variation in microclimate. Timber branches for climbing as well as hollow logs and rocks can also be incorporated into the enclosure design to provide the perfect habitat for the resident species of reptiles or amphibians.

Maintenance.

Once established, a bioactive system should thrive, but regular maintenance is required to keep the enclosure looking at its best. Plants will need ongoing moisture and should be watered according to the requirements of the particular species. Again, avoid over-watering, as this can cause a breakdown of the entire system. Automatic misting and fogging systems can be set up in the enclosure and many have built-in timers that can be set to spray the system at designated intervals throughout the day. Plants will also need to be pruned and trimmed from time to time to ensure they don't grow out of control, or that one species begins to take over. Pruning leaves and branches will also encourage new growth in the system. Fungi may also begin to grow in the enclosure as a result of spores in the soil. In most cases there is no need to be concerned about fungal growth as it is a natural part of any living system, however it can be removed if it begins to spread.

Soil custodians will need to be provided with fresh nutrients and food periodically. Adding new leaf litter to the surface of the substrate as it decomposes, as well as custodian pelleted food products, will ensure that invertebrate cultures remain plentiful. When feeding insect-eating reptiles, it is best to either tong-feed the animal, or remove it completely and offer feeder insects in a separate tub. Excess feeder insects such as crickets and woodies can easily hide in the enclosure and may begin to breed and feed on plants and foliage and can be difficult to remove once established in the system.

Animal Species.

We are fortunate in Australia to have such a wide

variety of native reptile and amphibian species available to us in the hobby. These have a diverse range of environmental requirements, so it is important to make sure they are housed correctly. The following breakdown provides some examples of Australian species that generally thrive in bioactive systems.

Tropical Forest System.

Amphibians: almost all native amphibians will thrive in a bioactive system if it is tailored to their specific requirements. Examples include: Green Tree Frogs, Red-eyed Tree Frogs, Magnificent Tree Frogs, Dainty Tree Frogs, White-lipped Tree Frogs, Peron's Tree Frogs and Eastern Dwarf Tree Frogs.

Lizards: Angle-headed Dragons, Boyd's Forest Dragons, Pink-tongued Skinks and medium-sized skinks such as *Lampropholis* spp. and *Eulamprus* spp. will all flourish in a well-planted bioactive system.

Snakes: Green Tree Pythons and Jungle Carpet Pythons are at home in a densely planted tropical enclosure. Larger plants with strong leaves must be used as Carpet Pythons will crush and flatten any smaller delicate foliage.

Arid or Temperate System.

Lizards: various types of geckos (e.g. *Nephrurus* spp. and *Oedura* spp.); Central Netted Dragons and other species in the *Ctenophorus* genus; *Egernia* spp.; *Tiliqua* spp.

Snakes: colubrid species, some small elapids and Diamond Pythons do well in a temperate, planted enclosure.

It is important to remember there is no single correct way of creating a bioactive system. This is an emerging part of the reptile hobby in Australia, and many techniques will continue to be developed and refined over time through trial and error. This article covers some of the key principles and basic steps involved in setting up a bioactive system. European and American keepers have mastered the art of bioactivity and as a result there is a wealth of information in online forums. It will be interesting to watch the momentum and interest continue to grow here in Australia, with many keepers' collections literally coming to life!

***Left:** a beautifully landscaped 'biopod'.*
***Above:** the author's own bioactive frog set up.*

Reptile Dietary Supplements

Essential additives, or unnecessary performance enhancement?

***Dr Thomas Vowell**, of Glenorie Vet Clinic, explains why the diet of many captive reptiles is lacking in vitamins and minerals*

One question I often hear around the topic of reptile supplements is: "Should I use calcium and vitamin supplements for my reptiles? Wild reptiles don't get supplements and I feed mine the best food I can buy!"

Not all orders or suborders of reptiles require dietary supplementation in captivity. For example, snakes and monitor lizards, which consume whole vertebrate prey such as rodents, rabbits, quail, etc., will obtain an appropriate balance of calcium and phosphorus (Ca:P) without the need for supplements. The skeletons of their prey items will contain sufficient calcium, and the livers will also be rich in other micronutrients such as vitamin A. However, dietary supplements are essential for omnivorous or insectivorous lizards and turtles. The simple reasons for this are that commercially-available invertebrates don't always contain the nutrients required by your reptiles, and the variety of food items available to free-living reptiles is far greater than that of those in captivity.

Food nutrient content.
Most commercially-available invertebrates have a Ca:P ratio that is too low to sustain the majority of reptiles (see table). The ideal ratio for most reptiles is 2:1, which means that the diet will contain twice as much calcium as it does phosphorus. If the ratio is too low, then the reptile will resorb calcium from its bones, leading to fractures and a wide variety of other medical problems.

Knowledge of the biology and captive care of invertebrate prey items is essential for successful management of this food source. Gut loading of the prey items is a practice used to correct the nutritional content of invertebrates, by providing them with a high nutrient diet prior to being fed out. In one study Fox Geckos (*Hemidactylus garnotii*) and Cuban Tree Frogs (*Osteopilus septentrionalis*) were fed crickets that had been gut loaded with a high calcium (8% dry matter) diet which increased the calcium content of the crickets from 0.2% to 1.3%. The Fox Geckos demonstrated a significant increase in body calcium, whereas the Cuban Tree Frogs showed no marked improvement.

Most studies have found that feeding crickets a high calcium diet (>8% Ca) is unpalatable for the insects, which retain much of the extra calcium in their intestinal tracts. For this reason, it is important to feed out crickets on a high calcium diet within a matter of hours, otherwise the additional calcium will pass through their gut and not be delivered to the reptiles.

Species	Calcium (mg/100g)	Phosphorus (mg/100g)	Ca:P ratio (ideally 2:1)
house cricket	**40.7**	**295**	**1:7.3**
mealworm larvae	**16.9**	**285**	**1:16.8**
superworm larvae	**17.7**	**237**	**1:13.4**
waxworm	**24.3**	**195**	**1:8**

Mineral composition of common, commercially-available invertebrates. Adapted from Doneley et al (ed.s), 2018.

The advantages of a free-living diet.
Obviously, free-living wild reptiles do not receive calcium or vitamin supplements as part of their natural diet. So, it would make sense that if we can provide their captive counterparts with conditions that are as close as possible to those of their natural environment, we would not need to give them supplements either. However, as hard as some reptile keepers may try, it is impossible to

'When choosing a supplement, consider what may be missing in your pet's diet.'

Image by bluedog studio.

perfectly replicate the natural habitat and diet in a captive situation. The very fact that reptiles *are* in captivity may cause stresses which can interfere with normal digestion and absorption of nutrients from their diet.

Take the example of free-living Central Bearded Dragons (*Pogona vitticeps*), which will consume arthropods, worms, small rodents, lizards, greens and flowers. A 2015 study demonstrated that their diet included approximately 60% insect matter (from nine different orders) and up to 16% plant matter. The composition of the diet can also vary seasonally depending on the availability of food items in their natural habitat. The use of supplements in captivity will assist by providing micronutrients missing from the less diverse captive diet, in addition to reddressing the Ca:P ratio.

What to supplement with and how to do it.
There are a number of brands of calcium and mineral supplements on the market. When choosing a supplement, it is important to consider what may be missing in your pet's diet. If you have good access to a commercial source of UVB or unfiltered sunlight, you should choose a calcium supplement that does not contain vitamin D, as too much vitamin D can cause abnormal calcification of soft tissues. Calcium supplements should also contain as little phosphorus as possible, to help maintain a Ca:P close to 2:1.

The most commonly recommended method of getting your reptiles to consume dietary supplements is to dust them on prey items. However, this is not as simple as it sounds. Too little calcium powder and your animals risk developing deficiencies; too much and the calcium can outcompete some micronutrients in your pets' intestinal tracts. In a study investigating the efficiency of calcium transfer, crickets were dusted with an unnamed product containing 11% calcium and 3.2% phosphorus, using one -eighth of a teaspoon of the supplement per 100 crickets. The calcium levels were measured as 0.12% three hours after dusting and only 0.08% after 22 hours. It is important to keep this in mind when feeding out calcium-dusted crickets. The insects should be dusted immediately prior to feeding out to achieve the highest levels of calcium transfer.

There are a couple of techniques you can use to apply nutritional supplements to the exterior of the invertebrate prey. Placing the prey and the powder(s) together in a clean container and using the 'shake and bake' technique works in most cases, however not all invertebrates will pick up adequate amounts of powdered supplement. If the supplements will not stick to the outside of the invertebrates, you could try placing them in a shallow dish with some supplement on the bottom to encourage your reptile to eat it.

Dietary supplements are a key ingredient to maintaining a healthy and balanced diet for captive reptiles. The selection of appropriate supplements and the method in which they are applied to the diet are important factors to keep in mind.

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What's NEW:

Miraculously providing simple explanations for things that are, in reality,

EXTREMELY COMPLICATED!

What is BRUMATION, and why won't my BEARDIE EAT in WINTER?

PLEASE EXPLAIN

Many inexperienced keepers become understandably concerned when their pet reptiles become lethargic and refuse to eat with the onset of cooler weather. At this time of year, reptile retailers and vets are inundated with calls from owners requiring reassurance that there is nothing wrong with their animals, and information on how to manage them during this period.

Dormancy is a strategy used by many different types of organisms to survive periods when the prevailing environment is not suitable for normal activity and growth. Metabolic activity is minimised and stored energy reserves are used to 'ride out' seasonally unfavourable conditions. Perhaps the most obvious example of this is deciduous trees, which use cues of reducing photoperiod and temperature to shed their leaves and enter a dormant phase in winter, during which their metabolic processes are pretty much halted. Bulbs and many herbaceous perennials also become dormant in winter. Similarly, hibernation is a familiar concept amongst mammals, and is utilised by many rodents, bears, bats and hedgehogs. This coincides with times when there is a shortage of food (and often also low temperatures) and is characterised by a dramatic drop in heart rate and respiration, a reduction in body temperature (often to a level close to ambient temperature) and torpor. Prior to entering hibernation, the animals prepare by consume large amounts of food, which is conserved in fat deposits. Hibernating bears can also recycle proteins and urine. Hibernation may last for days, weeks, or even months, depending on conditions and the species involved.

If it is imperative for warm-blooded (endothermic) animals to avoid a scarcity of food during winter, then this becomes doubly important for cold-blooded (ectothermic) animals like reptiles, which are unable to regulate their body temperature independently of the environment. At the very time when it is typically more difficult to find food, activity is inhibited by lack of sufficient warmth. Brumation is similar to hibernation, and its onset is brought about by similar climatic cues (together with barometric pressure and an innate 'body clock'). It usually begins around late autumn and entails a general lethargy and abstinence from eating. Many reptiles will seek out a suitable site for brumation (called a hibernaculum) that provides some insulation from the elements – some turtles will even brumate underwater.

Left: *many insects also exhibit periods of dormancy. Here, a large group of Boxelder Bugs (Boisea trivittata) emerge from a house after winter hibernation. Image by Melinda Fawver.*
Right: *Central Bearded Dragons. Image by Eric Isselee.*

So brumation is an entirely natural phenomenon, from which a reptile will emerge with the arrival of spring. But it is also a very stressful process, and may prove fatal under extreme weather conditions, or if the animal concerned is poor in physical condition or weakened by virtue of its age (either very young or old). Brumation may also be linked with successful or enhanced reproduction, as cool temperatures are associated with spermatogenesis in the males, and seasonal cycling of the females.

So what do you do in captivity? Well, first let's deal with juvenile animals that have not previously experienced winter. Many of these do not fully brumate, but merely slow down a bit and consume less food. In captivity, it is therefore a simple matter to maintain warmer temperatures and day length and keep them active and growing through the colder months. In this way, they are given a 'kick start' and are likely to be significantly larger then wild juveniles come the next spring, without having undergone the rigours of winter.

Why don't we just manage all our captive herps in this manner? Well, some keepers do provide a 'summer regime' throughout the year, and depending on the species and individuals concerned, this may work well for them (although not necessarily indefinitely). However, periods of natural brumation may increase the longevity of your reptiles. Furthermore, the decision may not be yours to make, as your animals may switch into brumation of their own accord, independent of environmental cues. In southern Australia, captive reptiles have been known to commence brumation as early as February or March, at which time there would have been no detectable drop in photoperiod or temperature. In addition, if you wish to breed from your animals, a period of brumation is probably strongly advisable.

However, in captivity animals that are brumating need not experience the climatic extremes possible in the wild – or for quite the same duration. In most instances, the potential

Not dead.... just dormant!

Brumation is used to avoid the extremes of winter, but what about when it gets too hot? Aestivation is a similar form of dormancy employed by some reptiles and amphibians, together with a variety of invertebrates, to survive hot and dry weather. This is often assisted by holing up underground in cooler, more humid conditions. Western Australia's Western Swamp Turtle (*Pseudemydura umbrina*) is notable for escaping the summer heat in this manner, and the Water-holding Frog (*Cyclorana platycephala*), which is widespread on the Australian mainland, buries itself in a cocoon of mucus, together with reserves of water stored in its skin and bladder. Aboriginals used the frog as a welcome source of drinkable water during extreme heat.

Dormancy can also be used to optimise the timing for new life. Many seeds remain inactive until germination is prompted by rising temperatures, moisture or fire. Similarly, hatching in some species of turtles (and possibly monitors and crocodiles) is delayed until flooding. Embryonic diapause (in which the development of embryos is suspended pending appropriate conditions for hatching) is also common amongst turtles and chameleons.

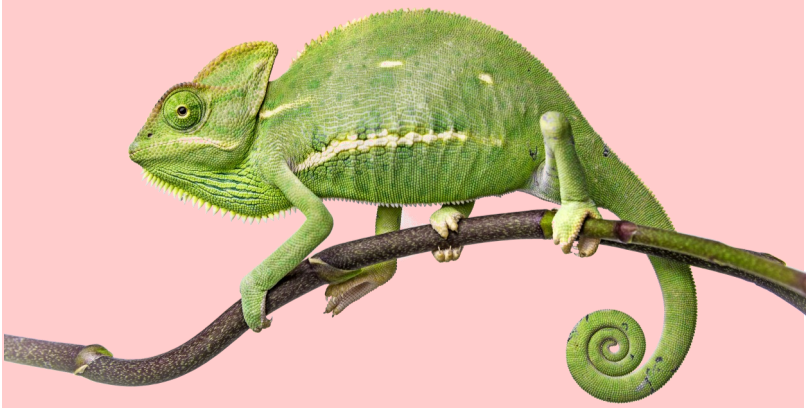

Image by Kuttelvaserova Stuchelova.

Above: *Sierra Garter Snakes (Thamnophis couchii) emerge from brumation. Garter snakes overwinter in huge numbers in large communal hibernacula. Image by Matt Jeppson.*

benefits of brumation can be conferred in as little as a six-week window, during which summer day time temperatures are reduced by around 5°C and heating is turned off completely at night. In most human dwellings this is unlikely to result in a night time minimum of less than 10-15°C, which is perfect for many species. If you heat your home during the night, then you may need to consider moving you reptiles to an area which is not heated.

progressively drop and raise temperatures over two or three weeks at the start and end of brumation, while others do it in a single adjustment. Generally, there seems to be little difference.

'If you are using a LOW-WATTAGE HEAT SOURCE that is not controlled by a thermostat, your animals are ALMOST CERTAIN to BRUMATE.'

So, although a healthy animal should withstand the rigours of brumation in the wild, you may choose to initiate a somewhat less risky form of brumation in captivity - or you could choose to maintain 'normal' (warmer) conditions and see if your animals enter brumation of their volition, at which stage you could manipulate parameters accordingly. You can also signal an end to brumation by raising temperature and increasing photoperiod at any time, or simply wait until the onset of spring to synchronise with natural seasonality. Some keepers prefer to

Now, it should be noted that if you are using a relatively low-wattage heat source that is not controlled by a thermostat, you are (perhaps unwittingly) creating a situation common amongst newcomers to the hobby in which your animals are almost certain to naturally brumate. The reason for this is that your heat source will continue to raise ambient temperature by a similar margin, however, if ambient temperature drops appreciably, so will the temperature experienced by your reptiles. For example (very simply), say your heat mat raises

temperature by 6°C, and that average summer daytime temperature is 25°C and winter is 16°C. The heated end of your enclosure will therefore be 31°C in summer but only 22°C in winter.

For obvious reasons, brumation should be avoided if possible for any animals that are sick or in poor condition. Likewise, any animal undergoing brumation which suffers a marked deterioration in condition should be 'reheated' as soon as possible.

The ability to digest food is an important consideration. If ambient temperatures are too low, your reptiles may not be able to digest food items in their gut, which can cause problems. Snake keepers routinely ensure that their animals' stomachs are empty (i.e. they have had a poo) prior to initiating brumation, and many other reptiles will go without food completely if brumating under natural conditions. However, if you inducing a mild form of brumation (as detailed above), with some supplementary heating, then your animals may benefit from continued, but reduced feeding. Regardless of food intake, clean drinking water is a necessity for all brumating reptiles, although the water bowl may not be a permanent fixture in enclosures for animals prone to respiratory infections (e.g. Shinglebacks).

Remember, brumation is not without risk, and it is also important to research the requirements of the species in your care. Many blue-tongue keepers simply move their animals indoors for the winter, in unheated enclosures, so they don't suffer the extremes of the external environment. Turtles (and other species that remain outdoors) may require an insulated container with appropriate substrate that retains a level of humidity, and it may also be advantageous to equip it with a thermometer. If in doubt, seek the assistance of an experienced keeper or reptile vet.

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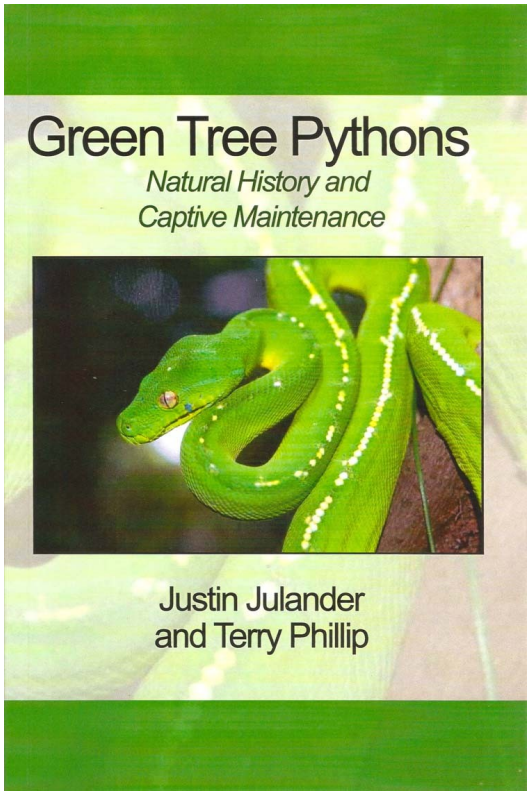

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Reviewed by **Michael Cermak.**

If Maxwell's *Complete Chondro* is regarded as the Bible for keeping and breeding Green Tree Pythons, then I wouldn't hesitate to call this book the New Testament. The authors draw heavily from research conducted in the last decade, mainly on Australian GTPs by Australian scientists, and this sets the book apart from any previous publication. Also, a lot has changed in captive management of the species since Greg Maxwell published his book some 14 years ago and this new volume suggests some innovative approaches.

Etymology, description, size, longevity, distribution, predation, behaviour, conservation and reproduction in the wild are all discussed in the chapters relating to natural history. The contents are informative and easy to read and understand. This part of the book is particularly important for those who have never witnessed a Green Tree Python in the wild. It explains their body design and function in three-dimensional habitat as well as other aspects of their ecology which are not obvious in captivity. The chapter entitled *Adventures in (Australian) Green Python Country* adds a nice little travelogue that us Aussies can relate to and enjoy.

The authors emphasise that ecological data should be incorporated into captive management for best results in maintaining healthy, happy, long-lived animals, and urge keepers, no matter how experienced, to 'look beyond the fact sheet'. The captive maintenance section covers all aspects of husbandry for both adults and neonates, while the captive reproduction chapter highlights recent progress in captive breeding techniques and sheds some sobering light on the not-so-wise practices of accelerated growth, overfeeding and much-too-frequent breeding. It's music to my ears, reading about a naturalistic approach to housing and behavioural enrichment that embodies real respect for these amazing snakes.

The following chapters deal with diseases and disorders, highlighting the huge improvements in husbandry, quarantine and veterinary care in recent years. Finally, the last chapter is devoted to the memory of Rico Walder, one of the best-known Green Tree Pythons breeders who left this world much too early. I had the pleasure of spending some time with Rico at Iron Range - an experience I will never forget – and I commend the authors for including this epilogue in their book.

About the authors:
Dr. **Justin Julander** is an Associate Professor at Utah State University with an interest in virology and antiviral research.

Terry Phillip has worked at the Black Hills Reptile Gardens for the past 20 years and has extensive knowledge and experience with a wide variety of reptiles.

Semi-adult GTP in early slough. All images courtesy Michael Cermak.

It's not EASY being GREEN.

Some interesting observations derived from captive Green Tree Pythons *(Morelia viridis)*.

***Michael Cermak** has been keeping and breeding Green Tree Pythons for many years, so he has had ample time to reflect on some intriguing aspects of their biology.*

The Red Shed.

In order to grow, snakes have to shed their old, and sometimes well-worn, skin. The frequency of shedding depends on the age of the snake, and growth rates, which are affected by the amount of food the animal consumes. Sloughing can also be induced by the presence of ectoparasites such as ticks and mites, and by physical injury to the skin.

How much attention do you pay to sloughed skins? For years, all I ever did with them was to pull them out of the cages and throw them into the bin. Until one day....imagine my shock and horror when I went to check my juvenile Green Tree Pythons in the morning and there was this red slough wrapped around a bamboo perch. Immediately, I thought blood! On closer examination I realised that the slough, being inverted as it comes off the snake, should also have left bloodstains on the snake. However, this wasn't the case; the snake was as clean as a whistle and happily resting on its perch. I examined it thoroughly, looking for some sign of injury or blood, especially around the mouth and cloaca, but found nothing.

In about five years following this event, I witnessed this phenomenon another five times – always with yellow juveniles up to six months of age. The occurrence has always been random, and not attributed to any particular snake, clutch, or anything that would fall into a pattern. The last five sloughs were pink rather than red, which really confused me. If it were indeed blood, I would expect it to turn dark red or brown after a few hours, but not pink. Each time, there was not a mark on the snakes and they all grew up into healthy sub-adults and adults. I asked around but no other GTP breeders had similar experiences, and that made me wonder if it was something 'tropical'.

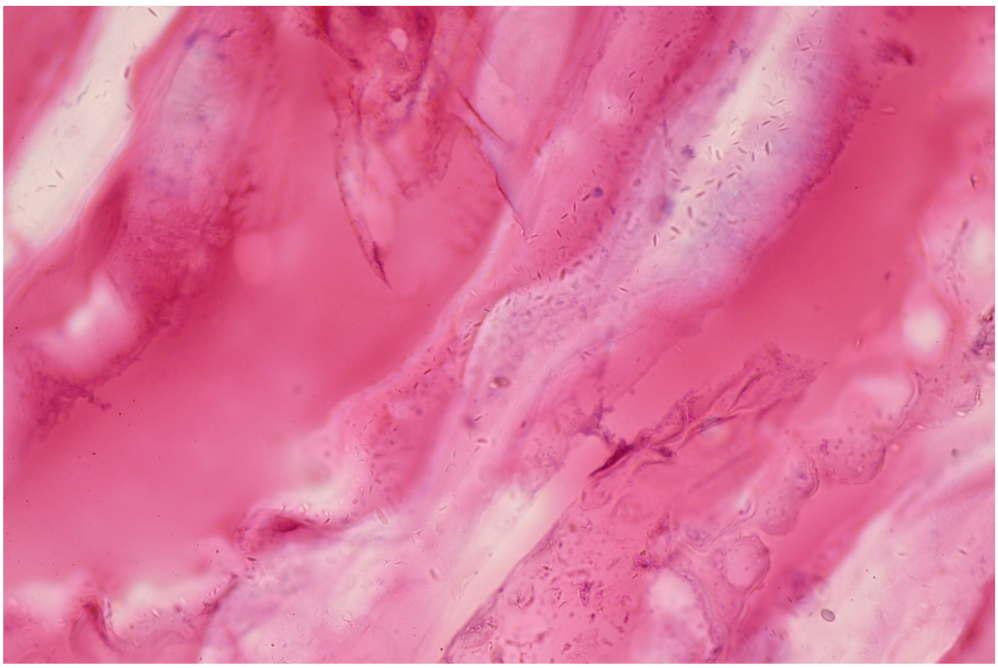
Finally, curiosity got the better of me, and I had some histology profiling done at the local hospital. After staining the samples, the truth was revealed under high magnification. The prepared material on the slides didn't contain any erythrocytes (red blood cells), but rather, small, pointed rods appeared lined up on the surface of the sloughs. These structures were actually bacteria, which most probably came from the environment (in this case the interior of the enclosure) rather than the snake itself.

It's not a world-shattering discovery, but worth noting for other breeders. If you do happen to find a red or pink slough, don't worry - there is nothing wrong with your snake. Besides, it could well be a bacterium endemic to the tropics, and may not be evident in cooler climates.

1., 2., & 3.: red slough has been witnessed on six different occasions - always with yellow juveniles up to six months of age.

Proteinaceous Plugs.

While on the subject of sloughs, I am sure every seasoned snake keeper has noticed those whip-like yellow bits attached to the sloughs of male snakes, in the region of the cloaca. What are they, what are they made of and what's their function? A quick search of available literature revealed that Dave and Tracy Barker (well-known US breeders) call them 'hemipenal casts'; others refer to them as 'hemipenal exuviae' (M. Simpson, 2010, pers. comm.), which essentially means the same thing; Greg Maxwell categorically states that they are not hemipenal casts, but rather 'sperm plugs'; and Rick Shine et al. (2000) talk about 'mating plugs' in garter snakes....but that is something different again.



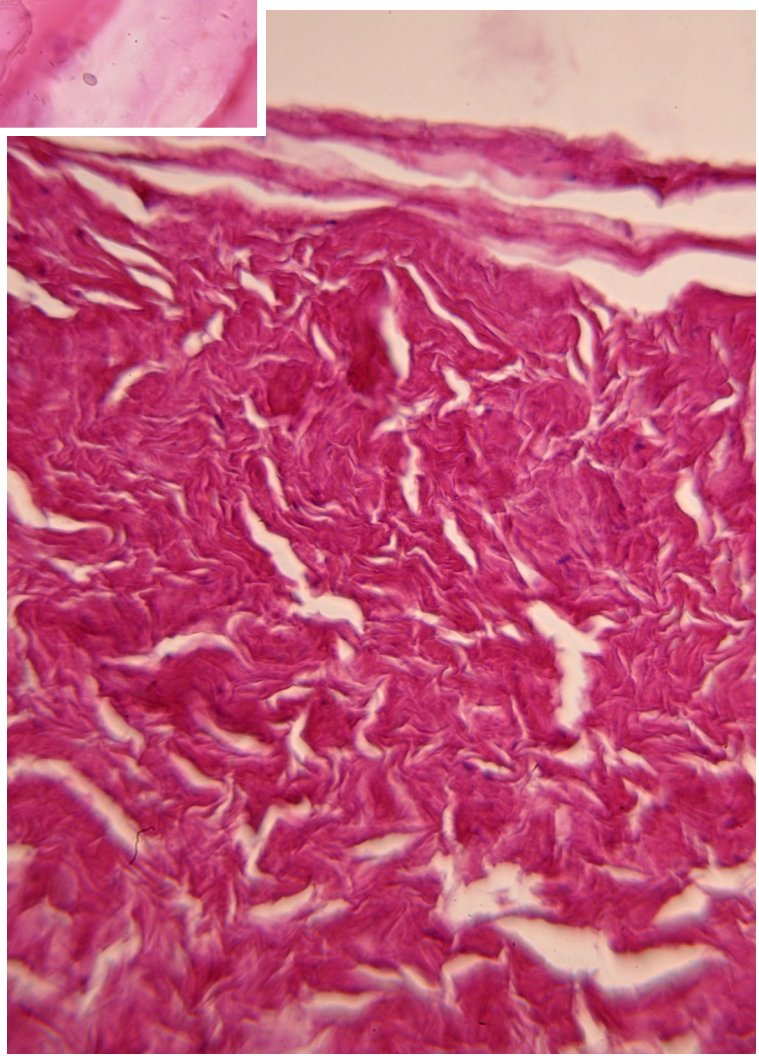
'The dark pink material is usually keratin—a protein.'

I first took an interest in these structures when a friend suggested that the ontogenetic colour change in Green Tree Pythons might be linked to the onset of sexual maturity. If the 'plugs' had anything to do with sperm production and this coincided with colour change, I would expect to see them on sloughs from 8- to 10-month-old males. I was a bit sceptical, believing juveniles of this age to be far from sexually mature, as this stage of development is normally reached at about 2.5 years. Nonetheless, I considered this an interesting concept, so I started collecting and examining sloughs. Not surprisingly, there were no signs of plugs until about 16 months of age, long after the colour change (but also well before sexual maturity). So much for this theory, but I was still keen to find out first-hand what the plugs were made of.

I had the opportunity to collect a very fresh slough from an adult male, as it came off the snake. The plugs were white, soft, sticky and very pliable. I snipped them off, mounted one of them onto a slide and examined it in floatation under a high-powered microscope. There were no signs of live - or even dead - spermatozoa. *Why should they be called 'sperm plugs'?* I asked myself. Another time, I collected plugs from three different mature males and had them prepared at James Cook University by Assoc. Prof. Jamie Seymour. The samples were processed in the histology unit at Cairns Base Hospital and after staining, we photographed the material and sent the images to experts for interpretation.

Dr Cathy Shilton, a veterinary pathologist, shed some light on the images. The dark pink material is usually some sort of keratin, and the layer of flaky strands at the surface is also suggestive of keratin, which is proteinaceous. The small blue dots regularly intermingled with the pink material are shrivelled remains of cellular nuclei. Spermatozoa in reptile histology appear as elongate blue lines, without the typical mammalian round head and thin tail, so it's most likely that the blue dots in the sample are the

Left: *histology slide showing bacteria (small, short, rod-like structures) on red sloughs.*
Below: *slides prepared from the 'sperm plugs' showed no signs of spermatozoa—dead or alive!*



remains of nuclei from sloughed dead keratinocytes. It stands to reason that a captive snake that is growing rapidly and frequently shedding the outer layers of its keratinised epithelium might accumulate plugs of keratin in the lumina of the inverted hemipenes.

In conclusion, it seems that the plugs are neither accumulated sperm, i.e. sperm plugs, nor hemipenal casts as such, although the keratinous material may at least be partially composed of the remains of hemipenal exuviae. To me, the term 'cast' implies something that retains the shape of the organ it sloughed off, not a sticky substance capable of stretching like chewing gum. Also, if they were hemipenal casts, one would expect them to appear on each and every sloughed skin throughout the snake's life, and they should also be present on sloughs from juvenile, immature males. That is clearly not the case.

GTPs and OCCs.

Returning to the process of ontogenetic colour change (OCC), this consists of permanent colour changes allied to the normal, progressive development of individuals of a species. This is typically associated with changes in size, habitat, reproductive status and other factors, and has been noted amongst a variety of organisms including aquatic and terrestrial invertebrates, fish (including the Nile Perch), birds and mammals, however it is doubtful whether a more spectacular example exists than the colour change exhibited by juvenile Green Tree Pythons (Emerald Tree Boas also undergo a remarkably

Left: *library of sloughs from the cloacal region of juvenile GTPs.*
Below right: *typical 'plugs' on male GTP slough.*

similar transformation).

The evolutionary significance of this mechanism is poorly understood, and the big question that remains is: why is it important for GTPs to have yellow or red babies? Wilson et al. (2006) suggested that the yellow juveniles live mainly along the rainforest edges, where they rest and hunt just above ground level for skinks and invertebrates whilst remaining less visible against the leaf litter and Guinea Grass from above. It has since been established that the juveniles also feed on small frogs, and although they may snap at insects passing by, bugs are certainly not part of their diet. In fact, no species of python is known to feed on invertebrates.

Upon changing to green in colour, the young pythons move into the rainforest canopy where they are now effectively camouflaged, and they also switch prey items from skinks and frogs to small mammals and birds. Wilson and his colleagues used the von Bertalanffy growth model to estimate the age of juveniles and suggested that OCC takes place between 0.9 and 1.1 years of age. They concluded that OCC appears to be size mediated, with snakes changing within a very limited size range.

I have been collecting data on OCC from captive Green Pythons since 2007. During this time I have amassed a large body of information from more than 60 individual snakes - a significantly larger number than were available to Wilson et al. Opinion was divided amongst my colleagues as to the trigger for OCC in Green Tree Python juveniles, so I decided to test whether there was a correlation with age and/or size. Because snakes are notoriously difficult to measure accurately, I chose to use body weight rather than SVL to quantify size. I also recorded the exact number of days that it took each snake to change colour.

'Why is it important for GTPs to have yellow or red babies?'

Importantly, my findings differ considerably from those of Wilson's study. Body weight at OCC ranged from 60-110 grams because the snakes grew at different rates, despite being subjected to the same feeding regime. However the timing was pretty constant; clutches were all hatched about the same time and all animals changed colour within a two week period. This indicates that OCC is independent of weight but is temporally triggered.

The twins I hatched in 2008 are a good example. They were 5.6 and 6.5 grams respectively at birth, which is about half the body weight of a normal neonate. Nevertheless, they changed colour shortly after their siblings, which were still much bigger at the time. The twins weighed 16 and 26 grams at OCC, whilst their siblings had attained a body weight of 40-62 grams.

We should also consider non-native races of the species. From my limited experience and information received from other GTP breeders, many of the non-Australian juveniles start changing colour at a very early age (as little as three months) and this process can last several months, or even years before it's completed. Because we don't have reliable information about the true origins of these non-natives, it's hard to say whether there are regional differences in the OCC. However, the OCC in Australian populations is temporarily well-defined and synchronized compared to non-natives, and the duration of the

colour change is also very short in comparison, being as little as four days from start to finish!

	beginning - weeks	duration - days
mean	38	8
mode	37	4
range	35-45	3-31

This table refers to data collected from 2007, 2008 and 2009 clutches. The modal values are more indicative as some individuals were slow to start feeding, resulting in a skewed mean value.

So, what could the temporal trigger be? There is a fundamental difference between climatic regimes on Cape York Peninsula and the equatorial rainforests within the species' distribution. Cape York is heavily influenced by seasonality (wet and dry, with fluctuations in temperature and photoperiod), whereas equatorial habitats in the north have a more uniform climate throughout the year. Seasonal variation might be instrumental in the timing and short duration of native GTPs' colour change.

I am well aware of the dangers of extrapolating from data derived from captive snakes, but if we accept that the colour change takes place in June/July (as it does in captivity), which is the onset of the dry season, then we can predict that this also coincides with a shortage of small frogs because they metamorphose during the monsoonal rains (January–March). It would therefore be perfect timing for the now-green juvenile GTPs to switch habitat and prey items.

Ontogenetic colour change is a physiological process controlled by either internal signals (e.g. hormonal activity) or by some environmental cues. It's a highly

speculative hypothesis, but the changing of seasons might just act as a temporal trigger to start the colour change in native GTPs.

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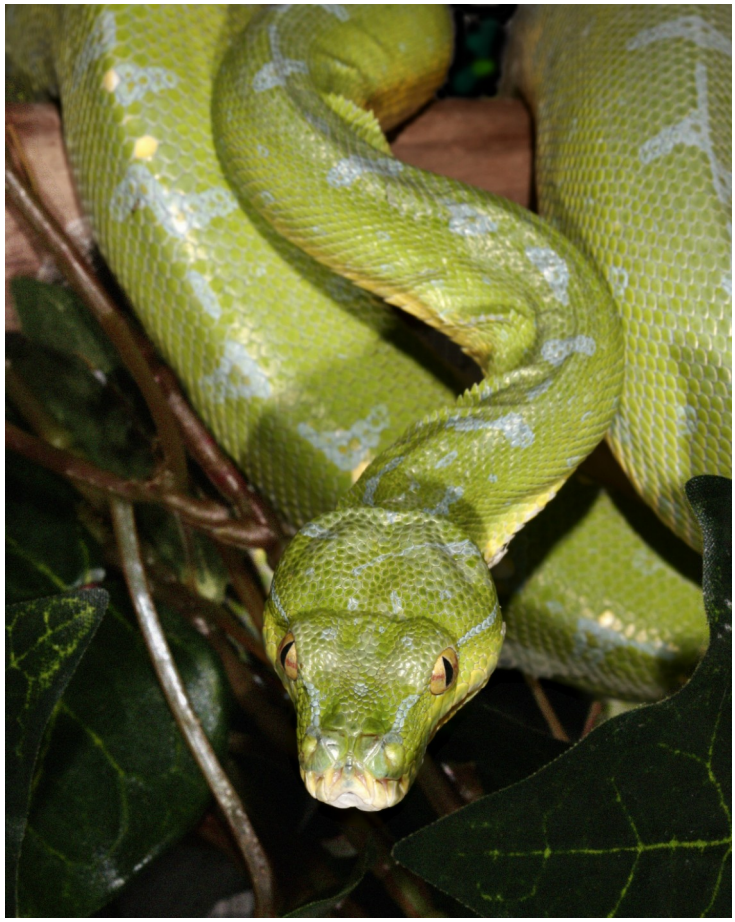
My thanks go to Assoc. Prof. Jamie Seymour for preparing the histological material and micro-photography, Prof. Rick Shine for his valuable comments and Dr Cathy Shilton for her professional interpretation of the images.



Above: *Sorong-locality GTP.*
Opposite page: *yellow and red juvenile GTPs prior to onset of OCC.*

‘The Tiger Snake waited very obligingly for its portrait to be taken, before slipping silently away.’

Two Indian Herpers in Australia.

Legendary Indian herpetologist Rom Whitaker and his partner Janaki Lenin provide an interesting perspective as they remember their trip to Australia in 2016.

“I don't ever want to see another reptile again,” Janaki muttered as her head slid across the back of her seat and came to rest on my shoulder. At any other time, I'd have been shattered by her words. We’ve been on so many reptile adventures together. But I understood what she meant. We had just completed a gleefully exhausting 'all you can see in two weeks' Australian reptilian extravaganza.

It all began in Melbourne when we plunged headlong into the crazy world of private snake collections. I'm familiar with obsessive collectors, but this was the first time I had met snake connoisseurs.

Nigel Souter has arguably the largest Tiger Snake collection in the world, with a representative of every population. I had dreamed of seeing the big fat black tigers of Chappell and Flinders Islands and here they were. His snake room holds 45 of every kind of colour variation, and some are so subtle that my colour-blind eyes couldn't spot the difference. Brown ones, black ones, some with markings, some without; Tiger Snakes don't come in dramatic colour morphs like tropical pit vipers.

At the time of our visit, his collection actually grew larger, as a Tiger Snake was giving birth to live babies. A youngster emerged tail first, and then the rest plopped out, wrapped in its yolk sac. After pushing its way out of the yolk sac, the little critter lay seemingly stunned for a few minutes. Yawning, it took its first gulps of air before slithering across the box to join its brothers and sisters. What the hell is Nigel going to do with all the babies? He doesn't sell them, but says he'll trade them for some other cool snakes. I bet he'll just get more tigers. I kinda sympathise with him though; he's probably making up for his snake impoverished childhood in New Zealand. In Nigel's backyard, fat and happy Tiger Snakes live in large outdoor enclosures with natural substrate and plants, as close to the wild as they are likely to get. One lay draped over a rock, soaking up the evening rays.

Down the road, Ross Howlet keeps an extensive collection of death adders, the Australian elapids that masquerade as vipers. I had found and photographed some in New Guinea many years ago, and I could appreciate the fine differences between the beige, tan, russet and camel tones of these beauties. The enthusiasm these men bring to their hobbies is infectious, and none more so than 'Mantid' Maik...

After feeding giant stingrays at the Melbourne Aquarium, we made our way over to the Melbourne Museum, where we met Australia's largest stick insect, thanks to Maik Fiedel. Janaki also got to hold and admire one of Australia’s most iconic reptiles, the delightful Thorny Devil. We had a long conversation with Mantid Maik and Adam Sapiano, our host and president of the Victorian Herpetological

Left: *Tiger Snake at Stony Rises. Image supplied by Adam Elliott and Adam Sapiano.*
Right: *Thorny Devil at Melbourne Museum. Image by Adam Sapiano.*

Society, about people's endeavours to keep Thorny Devils alive and thriving in captivity for extended periods of time. The obvious limiting factor is the ability to keep these creatures well fed - a huge challenge when all they will eat are ants, ants and only ants - and the Museum maintains several ant colonies just to feed this little lizard. There is also a naturally landscaped 'Forest Gallery' which houses breeding colonies of birds such as amazing bower birds and the really gorgeous Regent Honeyeater - another cool departure from the usual still life museum displays. The exhibit that took our breaths away was the fossil of a huge extinct tortoise carapace, *Megalochelys atlas*. It's billed as the largest chelonian to have ever lived. Even though I'm a herpetologist, I didn't know it's from the Siwalik Hills in India!

Our experiences around Melbourne weren't limited to private and captive collections alone. Adam Sapiano and his mate Adam Elliott had a real treat in store. Elliott has caught reptiles all over the country and has an uncanny sense of where to find what, which of course only comes from long years in the bush.

We drove two hours into the countryside to a place called Stony Rises. On our wish list were copper-heads, Tiger Snakes and brown snakes. Eventually, we pulled off the road at an abandoned, overgrown farm. We walked slowly around looking for places where a snake might be hiding. And there were plenty of potential hiding spots; tin sheets and tyres littered the place.

A few minutes later I turned over a promising piece of tin and, lo and behold, there was my very first wild Tiger Snake. Well, the snake was faster than

1. *Copperhead. Image supplied by Rom Whitaker and Janaki Lenin.*

2. *Meeting a Serval at Werribee Open Range Zoo. Image by Adam Sapiano.*

3. *Euan Edwards with Janaki and Rom in granite country near Tenterfeld, NSW. Image by Scott Eipper.*

this old codger and maybe it was better he did get away before I got bit! Still, I had my jolt of adrenalin for the morning and I joined the others who were working their way down the thick, bushy slope, as rabbits shot out of our way.

Suddenly Sapiano called out, “Here, come on over here!”

He was frozen to the spot and gestured to a thick clump of grass near his leg. “Check out the copperhead - first wild one you guys have seen, I hope.”

‘The COPPERHEAD remained CALM and CONFIDENT throughout.’

Yes it was our first, and a real beauty it was. Its shiny scales reflected the early sunlight as it calmly watched us; tongue starting to flick to try to figure us out. We spent the next ten minutes photographing this lovely snake which remained calm and confident throughout. We walked on, pushing through the bushes, and suddenly startled a couple of Swamp Wallabies that bounded out of our way in a hurry. We’d already gotten used to the big, flamboyant, squawking cockatoos in the eucalyptus trees.

It wasn’t long before Elliott shouted, “Tiger!”

We rushed over to where he was pointing at the dark, banded snake hiding its head in the grass. The whole black, gleaming length of its body lay exposed. We all chuckled, observing that it was a pretty dumb thing for a snake to do! No matter where in the world you are, you find some snake that does this. Elliott gently pulled him out into the open for some pictures. Although I was confident of his snake handling skills, we Indians aren't used to tailing snakes like you Aussies do. The Tiger Snake spread its neck in the classic elapid defensive pose, something very familiar to us folks from the land of the cobra. It then waited very obligingly for its portrait to be taken before slipping silently away. We were getting parched by then and headed back to the car through an old dry stream bed dotted with tufts of grass.

Both Adams said it was the driest they’d ever seen this swamp. A large Eastern Grey Kangaroo watched us suspiciously from the other side of the slope. Just then we all spotted another copperhead lying in the same fashion as the tiger – stretched out full length in the sun but with its head buried in the grass. Near it was another copperhead the same

Left: *Granite Leaf-tailed Gecko (*Saltuarius wyberba*). Image supplied by Rom Whitaker and Janaki Lenin.*
Right: *Pale-headed Snake (*Hoplocephalus bitorquatus*). Image by Scott Eipper.*

size. Is this how these elapids bask? Without disturbing them, we got some pictures and watched as they crawled next to each other, tongued a greeting and then disappeared together in the thick bush. Janaki and I were impressed by the beautiful sheen of their scales.

Elliott also found a baby Tiger Snake resting under a piece of tin. We took a few pictures of the tiny elapid, and Sapiano commented, "We don't know what it's capable of yet, so we're careful with it."

'In INDIA you see a fast-moving snake and you DIVE and GRAB it!'

This should be a more common refrain in Australia, where roughly 100 of the 140 species of native snakes are venomous. If you're snake hunting in America and India, you see a fast-moving, long, slender snake, and you dive and grab it. It's a colubrid. In India it's a ratsnake or bronzeback tree snake, and in America, it's a Coachwhip or Black Racer. In Australia, you don't dive on it kids -it's always an elapid! Which makes us wonder, what happened to colubrids in Australia? There's so few.

We headed back to Melbourne via a detour, as Elliott wanted to show us more of the bush. His sharp eyes spotted a Jacky Dragon on a stump, even as we were cruising, and we stopped for a quick photo opportunity. We had seen two of our main target species and more - we were chuffed!

Both Janaki and I have a particular fondness for monitor lizards and it was a pleasure to meet Elliott's Lace Monitors. He's sure his goannas know their names, another tantalizing indication of just how smart these lizards are - the smartest of all reptiles perhaps? Smarter than crocs maybe?

Next on the calendar was a day at the Melbourne Zoo, where Damien Goodall of the Reptile House welcomed us behind the scenes. Here we met good old pal Chris Banks and got to see their wonderful collection of critically-endangered Philippine Crocodiles. We don't have this species back at the Madras Croc Bank and I had never seen them before.

The really big social event in Melbourne was the VHS Expo. Janaki and I have been to reptile expos in different parts of the world and the VHS show was really well organized and patronized. While there was some serious buying and selling of beautiful, captive-bred reptiles, this was a time and place for like-minded people to get together and talk; bragging about the reptiles they've seen in the wild and what they are breeding in captivity, and of course, gossiping about some of the herp weirdos, both human and reptilian, whom we all know. It was a great experience for kids too, with plenty of interesting herps to see, along with the chance to hold a snake, touch a crocodile and attend some very lively talks and demonstrations.

The next leg of our Aussie tour started in Brisbane, where we met up with Steve Castell and his partner Mahalia Logan. No sooner had we set our bags on the floor of their living room than we were off on another adventure - a 200km drive out across the Great Dividing Range to Girraween National Park

with Scott Eipper and Euan Edwards, two of Steve's mates who were a source of great herp knowledge and entertainment.

We stopped several times on the way to our camp, mostly to check out piles of rocks on little hillocks, searching for whatever herps we could find and incidentally enjoying the sight of cockatoos and kookaburras - iconic Aussie birds, though everyday sights to these guys.

It was on this trip that we experienced a truly Aussie institution - the 'swag'. In India, we'd have called it a bedroll. In the old days of long distance train travel, every family had a couple of these; nowadays they are a rarity. But it wasn't bedtime yet, not by a long shot. Scott gestured towards a pool that he said might have a resident platypus. We wanted to see this egg-laying, venomous mammal, but it was keeping a low profile. We had a couple of kangaroo hot dogs for dinner and then headed out, head lamps blazing, to search for herps.

There's nothing like going to a new location with a couple of dudes who know the place and the creatures well. Those few hours we spent on the rocky, forested hillocks, walking slow and calling out to each other if we spotted something, were magical.

'We had a couple of KANGAROO HOT DOGS for dinner and then headed out, head lamps blazing....'

"Rom, Janaki, come here," Euan shouted. We picked our way over boulders to where he was beaming his light on the trunk of a big paperbark tree.

"Just check this out, it may be a first for you," he said. And wow, what a lizard - a leaf-tailed gecko. We'd seen them in pictures, but it was even more fantastic in the flesh. I gently nudged it onto my hand as we vain herpers are bound to do, and got a photo taken. We honed our search technique and over the following hour found a dozen of these wonderful geckos, both males and females, some with damaged tails.

We made it back to camp after midnight and, just before tucking ourselves into our luxurious swag, made the acquaintance of a possum that was nonchalantly checking for scraps under the picnic table. It's such an immense pleasure meeting animals who aren't scared shitless of nasty humans. The night sky showed no sign of any city or town nearby. During the night, we were gently awakened by kangaroos grazing all around our swag – an experience Janaki will never forget.

Next morning, we awoke to a cool predawn chorus of cockatoos and magpies, instead of our dratted Indian hawk-cuckoo, so aptly named the 'brainfever bird'. We went quietly down to the big pool in the stream and there was 'our' Platypus, diving out of sight when we appeared. But then he (she maybe?) came to the surface again and did a few rolls before heading off to the other end of the pond. If we were 'life-listers' Janaki and I would have had our notebooks out. But we just stared at the water dumbstruck by that magic moment. We walked upstream and a turtle plunked into the water from the bank. Scott said it could have been a Bell's Turtle, one of Australia's rarest.

On the drive back to Brisbane, Euan entertained us with some of his incredible stories of herping in Africa and the USA, including getting nailed by a Green Mamba, a puff adder and a Pygmy Rattlesnake. I started talking about my snakebites, and Janaki just rolled her eyes in despair.

Suddenly Euan swerved and jammed on the brakes. "An eastern brown; just missed it, there goes the tail!"

We stopped and whacked the bushes for a few minutes but it was gone. We were disappointed to have missed an opportunity to see this iconic snake - that would come later.

I had wanted to meet croc colleague Gordon Grigg, who had said he would be in the vicinity helping a research team catch koalas. Janaki nudged me to ask him if we could watch. Bill Ailes, the main researcher from the University of Brisbane, agreed and that's how Steve, Janaki, and I found ourselves watching the team at work. While we were waiting for the climbing gear to get organized for the capture, I spotted a Green Tree Snake. Since I could identify it from my days in New Guinea, I made a clumsy dive and pulled it out of the bushes.

The koala was clinging high up in a tree and the catchers were attempting to knock it off. They needed more hands, so Steve and I volunteered our services and held the safety net. Once the koala was bundled into a sort of cat carrier, Vere Nicolson, a vet from Dreamworld with plenty of koala experience, arrived to remove the radio transmitter. The researchers are learning a lot about how koalas cope with drastic seasonal changes.

Early next morning, Steve and I went out to a spot where he had spread old tin sheets all over a pasture. Walking through the tall, dew-soaked grass

I heard a bird whose wonderful rambling song reminded me of our Malabar Whistling Thrush. Steve told me it was a butcherbird. With curious cows watching us, we turned over a few tin sheets before we found a beautiful Eastern Striped Skink. Under the very last piece of tin was a fine metre and a half long Red-bellied Black Snake, now one of my favourite snakes in the world. It has the beautiful black sheen of a Florida Indigo Snake and an easy-going temperament. Steve commented that this species was a good introduction for someone starting to handle venomous snakes.

While night cruising, we found the first Pale-headed Snake I had ever seen; a beautiful snake, flattened onto the bark of a big old tree, their favourite habitat. Then a Small-eyed Snake and several very fine looking velvet geckos. Steve wove erratically along the deserted road, trying to squash every one of the disastrously invasive Cane Toads under his tyres.

Next day back at Steve and Mahalia's house, as I struggled to hold an unbelievably strong and slippery Land Mullet, Steve told us a cautionary tale. One of his mates, new to herps, had picked up a Land Mullet, derisively remarking that it was 'just a skink', and let it bite the webbing between his thumb and finger. The powerful lizard chomped down hard, did a death roll, ripped off a chunk of skin, and bolted it down before anyone could say, "Hell!"

That's a Land Mullet for you; a skink with Komodo Dragon attitude.

We also visited Steve's friend Kris Smith, who has

Above: *a Robust Velvet Gecko (*Nebulifera robusta*) found on a smooth-barked gum tree. Image by Scott Eipper.*
Below: *'swagwoman' Janaki catches some zzzs at Girraween. Image supplied by Rom Whitaker and Janaki Lenin.*

Left: *a Spotted Black Snake (*Pseudechis guttatus*) spotted by Euan Edwards. Image by Scott Eipper.*

some of the largest and most iconic of Australia's elapids including Tiger Snakes, Coastal and Inland Taipans and the especially impressive Mulga Snake, also called the King Brown. The Inland Taipan is the world's most venomous snake, and is Australia's rival to the King Cobra. At 2.5 metres long, it may not be quite as large, but the toxicity of its venom far exceeds that of the King Cobra.
Later that day, Steve and I went down to the Brisbane River and cast a line with a piece of boiled shrimp on the hook. This was the first time I've used boiled shrimp for bait and in two minutes I had a catfish fighting on my line. The fisherman in me was excited and I resolved that I had to try this trick back home in India for mahseer, our favourite fighter.

"It's an EASTERN BROWN SNAKE. Good thing you poked a stick and not a finger!"

On our last day in Australia Steve got a rescue call. We went to a new housing development and Steve pointed out how a lot of these new houses were being built in the heart of good snake habitat. "And this leads to trouble - we're getting more and more calls every day. At least most of them call one of us rescuers instead of lopping the snake's head off, which was standard practice ten years ago."

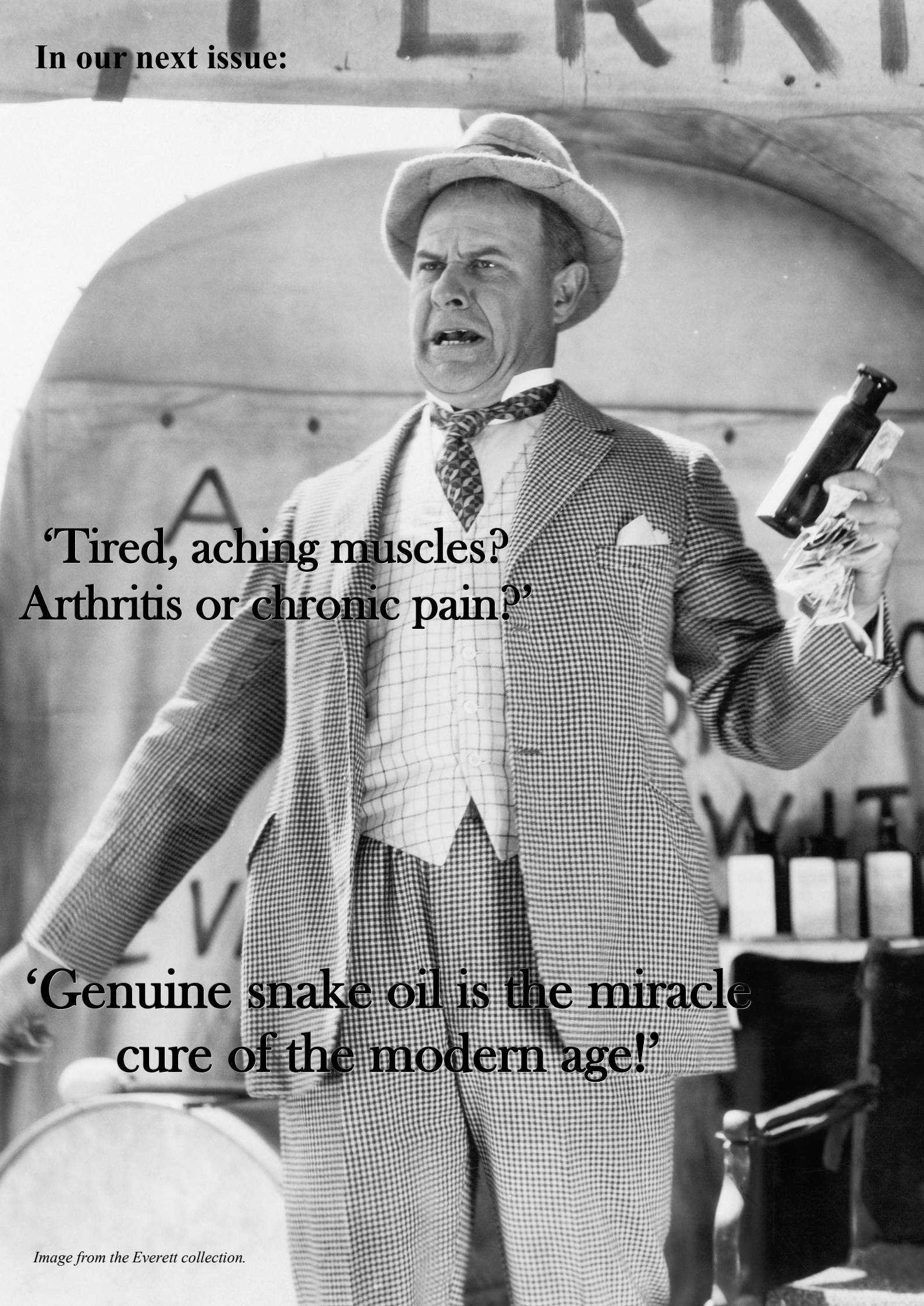
The lady who had called for assistance pointed to a hole under her garage where she saw the snake disappear. Steve suggested using a mouse to entice the snake out, but stupidly I thought that we could dig it out. Steve made the mistake of listening to my advice. While he checked around the side of the garage, I poked a small stick in the hole and....zap! A snake's head appeared and grabbed it. I shouted to Steve who dashed over and said, "It's an Eastern Brown Snake. Good thing you poked a stick and not a finger!"

I was totally impressed with the brown snake and its feistiness. Scary indeed. The hole went pretty deep into the foundation and the snake wasn't going to come out anytime soon. Reluctantly, we left the spot, reassuring the lady we'd return if she saw it again.

Perhaps the most unforgettable Australian experience I had was visiting the 'Reptile Room' of a high school. Marcus Whitby, a teacher at Lilydale High School, was always a herper and found that a big percentage of his students were keen on reptiles and amphibians. Starting with a few lizards and snakes in aquariums, the school now boasts a large, dedicated herp room with an impressive collection of reptiles, amphibians and insects, impeccably cared for by the students. Under development is a naturally landscaped outdoor enclosure, already full of side-necked turtles. Totally awestruck, I could only remark that this great achievement has gotta be widely publicized and emulated!

After such a packed, exciting itinerary, I couldn't argue with Janaki about seeing enough creatures. After a long pause, she said wistfully, "We need to come back. I haven't seen an echidna yet."

In our next issue:



‘Tired, aching muscles? Arthritis or chronic pain?’

‘Genuine snake oil is the miracle cure of the modern age!’

Image from the Everett collection.

Snakes that shiver.

Incubating pythons turn up the heat!

Conservation biologist and author ***Kit Prendergast*** *examines a physiological feat unique amongst reptiles.*

Reptiles are often described as 'cold-blooded', however this scientifically inaccurate term is more appropriately replaced with ectothermic', which better describes their thermoregulatory strategy. They rely on behavioural means to regulate their body temperature, which is thus largely determined by the temperature of their environment. This contrasts with 'endothermic' animals, which have evolved a thermoregulatory strategy whereby their bodies are maintained at a relatively high, constant temperature independent of the environment through endogenous heat production; that is, through metabolic activity, which generates heat as a by-product. Usually, we classify herps (non-avian reptiles and amphibians) as ectothermic, and mammals and birds as endothermic. But, as with most things in nature, there are often exceptions to the classifications and categories we erect….in this case, endothermic snakes!

For endotherms like ourselves, as well as other birds and mammals, one way to ramp up our heat production when we're cold is by shivering; rapidly contracting the body muscles in a physiological activity described as 'shivering thermogenesis'. Muscular activity generates significant heat, and usually when we engage in physical activity, this heat production is a 'waste' of energy: we want all the energy generated through our metabolic activity to do 'useful' work like run, jump, swim or cycle. But when we're cold, we have the ability to automatically increase heat production through shivering, which is muscular activity performed purely to generate heat. However, mammals and birds are not the only animals capable of generating heat through shivering thermogenesis – pythons can do it too.

Most of the time, pythons are your typical reptiles: their body temperature largely conforms to that of their environment. When it's cold they're cold, and will seek sunny areas in which to bask and rocks heated by the sun, to warm up through radiative and conductive heat exchange respectively. Most reptiles, being ectothermic, cannot incubate their eggs, which are typically laid in nests dug in areas that receive warmth from the sun. But a special exception occurs for brooding female pythons, which can incubate their eggs by heat generated through shivering.

Shivering has been well-studied in one of the best known of Aussie pythons, the Carpet Python (*Morelia spilota*), and particularly the Diamond Python (*M. s. spilota*). Peter Harlow and Gordon Grigg were the first to publish their detailed observations and measurements of a brooding female Diamond Python in 1984. The fact that this phenomenon was only documented fairly recently in one of Australia's most popular reptiles can be put down to a lack of successful captive breeding (until recently) coupled with the animals' naturally shy disposition. Harlow and Grigg noted that at the slightest disturbance – visual or vibrational – their female would cease shivering.

Whilst brooding, their captive python raised her body temperature to 32-33^{o}C, which was as much as almost 7^{o}C higher than ambient temperatures. She achieved this by repeated shivers (up to 50 per minute), each consisting of a series of muscular contractions involving the whole body. There was a definite daily rhythm to this process, with shivering rate, oxygen consumption and thus body temperature all peaking in the late

Below left: *a Burmese Python with her clutch of eggs. Image by Paul Tessier.*
Right: *shivering has been well-studied in the Diamond Python. Image by fivespots.*

evening (6-10pm), then steadily declining shortly after midnight, and being lowest in the early morning (3-6am), with shivering ceasing around dawn. When ambient temperatures were around 28°C, the python could maintain her body temperature at 32-33°C for 12 hours each day. At lower ambient temperatures, she was still able to sustain a temperature of 32°C, but for a shorter duration of eight hours.

Shivering thermogenesis is not a quirk of captive conditions but has also been demonstrated in the wild. Slip and Shine's studies on Diamond Pythons in the wild found that brooding females also used metabolic heat production to maintain high, stable body temperatures within a narrow range (around 31 °C), which was generally 9 °C above ambient temperatures, but occasionally up to 13 °C higher.

The energetic expenditure and metabolic activity involved in this activity is far from trivial: Harlow and Grigg examined their female python's oxygen consumption when the snake was no longer brooding (under identical ambient temperatures) and found it to be just 4.8% of her maximum rate when incubating her clutch! As such, metabolic rates of brooding females can be 21-fold higher than when they are non-brooding. The energetic cost was evident when they monitored her weight: after 52 days of brooding and daily shivering, the female had lost 278g (7% of her body weight) compared with her weight two days after oviposition. It was noted that she also fasted the entire time she was brooding, and hence no energy was replaced through diet, but none of the resultant weight loss was due to voiding faeces or urine. Later, Slip and Shine reported that female Diamond Pythons lost over 15% of their post-oviposition body weight while brooding. The high energetic expenditure is likely why females typically do not breed every year.

Given the energetic investment in shivering thermogenesis, we would expect that there is a benefit to this behaviour, and indeed, both field and lab studies have found that this behaviour is clearly adaptive. The resultant higher temperature-mediated developmental rates have been shown to induce earlier hatching, and the high incubation temperatures have also been shown to enhance offspring viability and quality. Pythons in particular have often been shown to be very sensitive to low temperatures during development, with embryos

'Shivering thermogenesis induces **earlier hatching** and enhances offspring **viability** and **quality**.'

dying when temperatures are too low. Experiments on artificially-incubated python eggs have suggested that at temperatures below 30°C, eggs take longer to develop, and fewer successfully hatch; hatching ceases altogether if eggs are incubated at 25 °C or less, with little signs of development.

The faster developmental rates that occur under higher temperatures

Left and below: *albino Darwin Carpet Python with her clutch. Images by R.M.T.*

generated by maternal endogenous heat production may also have benefits for the mother python. For, although shivering thermogenesis certainly entails a metabolic cost, it also means that by minimizing the duration of the incubation period (during which most females fast), the female will have more time to feed and increase her body mass before the onset of winter and the next breeding season. Similarly, earlier hatching may also benefit the offspring in allowing them to have a longer feeding period prior to winter, as well as assisting them to more rapidly attain a body size that makes them less vulnerable to predation, and even ultimately attaining sexual maturity at an earlier age.

Shivering thermogenesis also enables snakes to extend their distribution into cooler latitudes. For example, it appears that this behaviour allows *M. s. spilota*, which has by far the most southerly distribution of all Australian pythons, extending as far south as 37.5 ^{o}S in Victoria, to occupy areas where ambient temperatures would otherwise preclude successful hatching. Comparisons between pythons in the northern hemisphere have also indicated that species that frequently demonstrate shivering thermogenesis have ranges that extend to higher latitudes than their non-shivering counterparts.

Shivering thermogenesis has been recorded in all genera of Australian pythons, but it is unknown whether all members of Pythonidae are capable of this physiological feat. There are contradictory reports for different species, but failure to observe this behaviour does not mean that a species is incapable of or doesn't perform shivering thermogenesis. For some species like Reticulated Pythons (*Python reticulatus)* and African Rock Pythons (*Python sebae*), the ramped up metabolism necessary to generate heat is really only detectable by measuring oxygen consumption and heat production, but for Burmese Pythons (*Python bivittatus*), their thermogenic activity is evident as they rhythmically shiver and twitch their muscles. Failure to observe shivering thermogenesis can also be attributed to the sensitivity of brooding pythons to being observed and disturbed, as well as the facultative nature of this behaviour, also known as 'facultative endothermy'. Due to the high energy expenditure involved in endogenous heat production, it is unsurprising that brooding pythons only engage in this physiological activity when environmental temperatures fall to levels which may jeopardise the development of their offspring. Female Water Pythons (*Liasis fuscus*) will brood their eggs and transfer heat by shivering thermogenesis when their nests are located in tree root boles where ambient temperatures can be variable and quite low, but if their eggs are laid in the abandoned burrows of varanids, these provide a favourable, warm, stable environment for egg development, and the females need not brood or heat their eggs. Likewise, although detailed reports

of shivering thermogenesis exist for Ball Pythons (*Python regius*), under favourable ambient temperatures, such as those found in burrows in their natural distribution in Western Africa, they seldom shiver. We can therefore predict that species that have access to incubation environments that provide warm, stable thermal conditions will rarely, if ever, shiver, whereas those inhabiting higher latitudes or which don't have access to warm nesting sites will commonly employ this strategy. Under natural conditions tropical species may rarely experience ambient temperatures that require them to employ shivering thermogenesis, but still the capacity to do so would be clearly beneficial as a 'fail-safe' mechanism if a female is confronted with cool, cloudy weather conditions or an inability to locate a well-insulated nest site.

'Pythons are **unusual** in the amount of effort they put into **caring** for their clutch.'

Even when shivering thermogenesis is not observed, this doesn't mean the eggs are exposed to the vicissitudes of the environmental temperature. Instead, like other reptiles, female pythons have adapted to use behavioural means to ensure their clutch is maintained at a favourable temperature. For example, Ball Pythons (*Python regius*) and Spotted Pythons (*Antaresia maculosa*) will bask in the sun, absorbing the sun's radiant energy, and then press their warm bodies against their eggs so that heat is transferred by conduction. Even species that do regularly employ shivering thermogenesis will supplement this with heat gained from basking. In south-east Australia, studies using miniature emperature-sensitive radio transmitters implanted into Diamond Pythons found that brooding females maintained high, fairly constant body temperatures during the two-month incubation period through shivering thermogenesis assisted by brief basking spells lasting between 30-60 minutes on most mornings. Supplementary basking is especially important for females that nest in locations that are less thermally buffered. Radio-telemetry studies of Western Carpet Pythons (*M. s. imbricata*) in south-western Australia found that females that nested under the rootballs of fallen trees, which are relatively exposed to the elements, would occasionally bask in addition to shivering, unlike females nesting in enclosed, thermally-buffered rock crevices or sites well insulated by leaf litter and receiving thermal radiation from the sun.

Nevertheless, a key advantage of endogenous heat production is that females can incubate their eggs even when they cannot derive warmth from the sun. On cold or cloudy days, female pythons can still maintain high body temperatures and thus incubation temperatures. Moreover, females using shivering thermogenesis don't have to leave their eggs for extended durations to bask, which would leave the clutch exposed to predators and subject to cooling, as well as increasing the female's vulnerability to predation.

Not only are pythons unusual in their ability to raise their body temperature by physiological (as opposed to purely behavioural) means, but they are also unusual in the amount of effort they put into caring for their clutch. For most reptiles, especially those that are oviparous, investment in their offspring ends once they deposit the eggs, which are left to the vagaries of the environment and subject to temperature extremes and predation. Pythons – including species in which shivering has not been documented – invest a lot more in maternal care, as they remain with their clutch after it is laid, coiling tightly around the eggs after oviposition. In this way the brooding female pythons both guard and incubate the eggs. Although some other reptiles are known to attend to their eggs, the physiological feat of producing heat metabolically via shivering thermogenesis is exclusive to Pythonidae, the 'hot-blooded' herps.

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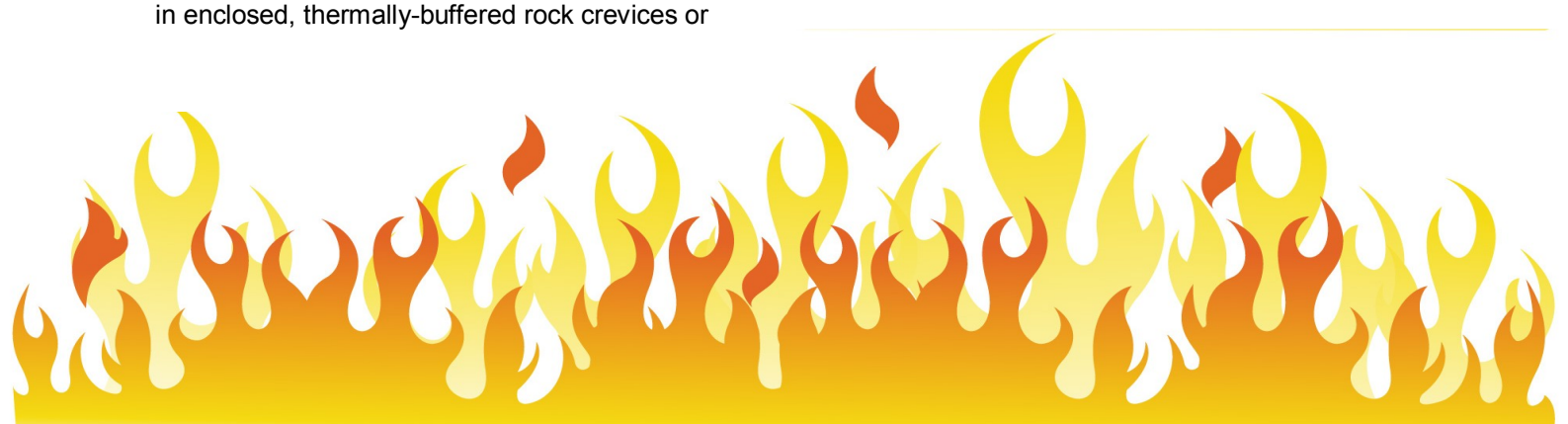

Long-distance Lizards.

PhD candidate **Gerrut Norval** and Associate Professor **Michael Gardner** from the College of Science and Engineering at Flinders University detail some instances of 'vehicular rafting' and point out the potential risks involved.

Gerrut Norval recalls:

As I was driving down Bower Boundary Road, a dirt road leading to our study site in the Mid North region of South Australia, in the late afternoon of the 5th of December 2017, I spotted a Central Bearded Dragon (*Pogona vitticeps*) basking in the middle of the road. Their habit of freezing while they judge whether you are a threat or just a passer-by makes these lizards ideal photographic subjects, so I stopped to add some more photos to my growing collection.

I took a few photographs and then decided to try to capture the lizard to inspect it for ticks. I was too slow! The beardie had evidently made up its mind that I was a potential threat and took off at high speed past me and under my car parked at the side of the road. I checked underneath the car to see if it was still there, but saw nothing. Concluding that it had re-entered the roadside vegetation, I got back in the car and continued on my journey, stopping for fuel in Kapunda and then for bread in Adelaide, before arriving home in the early evening.

Four days later, in the afternoon of the 9th of December, my wife and I returned from grocery shopping to be 'greeted' by a bearded dragon in the driveway leading to our home in Clarence Gardens, a suburb of Adelaide. It ran past us to the residents' parking area, and a few minutes later we were surprised to find it in the right rear wheel rim of our car. I caught the lizard, which I immediately assumed to be an escaped pet, since I have not seen any bearded dragons in the neighbourhood. So I took it to Simon Adamczyk, a friend who lives nearby (and owner of 'Animal Relocation & Education'), for some advice on how to deal with the 'escapee'. As he examined the lizard, he became increasingly doubtful that it had escaped from

'The beardie ran past us, but a few minutes later we found it in the WHEEL RIM of our CAR.'

Below left: *Central Bearded Dragons make great subjects for photography, because they are fairly large and are often quite approachable. Note the missing toes on the left hind foot of this individual.*
Above: *it may have been pure coincidence that the dragon returned to the vehicle it had arrived with, but we suspect that it chose the 'shelter' it considered familiar and safe. All images by Gerrut Norval.*

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captivity. For starters, it was a Central Bearded Dragon, while most of the pet beardies he deals with in Adelaide tend to be Eastern Bearded Dragons (*Pogona barbata*). He also pointed out that the lizard was extremely defensive when approached, which is not the normal behaviour of a pet. We then noted that the lizard had suffered toe-loss on its left hind foot at some stage. I decided to check the photos I had taken a few days earlier. And there it was; the 'escapee' turned out to be a stowaway that had travelled about 150km from Bower to Adelaide hidden somewhere under my car! The next day, I returned to the spot where I had first seen the lizard earlier in the week, and released the well-travelled bearded dragon.

Michael Gardner comments:

Late Professor C. Michael Bull once reported on a Gidgee Skink (*Egernia stokesii*) that had travelled about 500km from Camel Hill, near Hawker in South Australia, to Adelaide. Additionally, Gerrut previously described an instance of a Pacific House Gecko (*Hemidactylus frenatus*) in Taiwan that travelled on the outside of a car. As amusing as these accounts may be, such incidents are no trivial matter. Parasites and other pathogens can easily be introduced into new localities along with these 'travellers', and as the current bobtail flu in *Tiliqua rugosa* demonstrates, the potential results can be devastating. Therefore, a word of caution and plea for those of us who venture into the wild; time is not the only traveller, so we have to do what we can to minimise the risk of bringing back more than we bargained for.

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Above left: *it was the tell-tale missing toes that ultimately solved the mystery, and ensured that this travelling beardie could return home.*
Left: *once back in the wild, the lizard immediately settled down and returned to being the perfect photographic model.*

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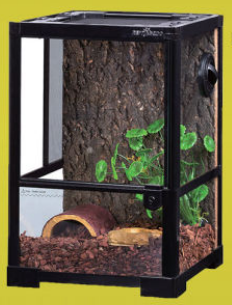
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LL2010 - 10W	LL5010 - 10W	LL1010 - 10W
LL2015 - 15W	LL5015 - 15W	LL1015 - 15W
LL2025 - 25W	LL5025 - 25W	LL1025 - 25W
LL2030 - 30W	LL5030 - 30W	LL1030 - 30W
LL2036 - 36W	LL5036 - 36W	LL1036 - 36W

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Photograph courtesy of Dr Joshua Llinas