ANDYSEZ 48

THE GREEN SICKNESS – *LA MALADIE VERTE* OR *LAMPENFLORA*

PART 1

- Andy Spate

Significant lampenfora and fern growth around a powerful cave light

Late last year I sent out a plea to cave managers across Australian and New Zealand through the ACKMA email list, asking people to share their experiences and recipes with chemical control of *lampenflora*. I received feedback from many people – but there were a surprising number of non-respondents. Some cave managers who I know have been actively attempting to control or reduce *lampenflora* did not respond – disappointing because we must learn from each others successes and failures. That is what ACKMA should be about! However – thanks to all those who did respond.

Hopefully the paragraphs below and in the next ANDYSEZ adequately summarises the ideas from all who did send in their ideas. Please note that I have lightly edited the various contributions to make them more readable, corrected spellings and so on. Any complaints to our esteemed Editor! It may also be worthwhile having another look at ANDSEZ 6 (ACKMA Journal No. 9, June 1992, p 23-24).

When we illuminate a cave so that our visitors ('clients' in modern management-speak) can see it, we are creating an artificial environment conducive to the growth of plants. Usually our lighting levels are such that we only support primitive plants – algae, fungi, mosses and so on. However, sometimes, our light levels are such that we are growing higher plants and chainsaws will be needed shortly!

In many cases – if we are growing plants – this is an indication of poor lighting practices. This is not the whole story, however. Once we have a substrate (light and moisture) we will inevitably get plants – *lampenflora* or *la maladie verte*! We will discuss the subject of cave lighting practice below.
We have the guides, visitors and natural air currents introducing spores, and sometimes seeds, into our supposedly 'pristine' environment. We might even be altering temperature and humidity regimes such that plant growth is further encouraged. Thus we may need to control the invasion by green and soggy things – and sometimes animals that may opportunistically feed on our new and artificial pastures to the detriment of our original cave-dependent inhabitants.

How might we seek to limit these problems? We could:

1. turn off the lights
2. reduce the levels of lighting,
3. change the characteristics of the lights,
4. use light to sterilise the lighted environment,
5. think about placing the lights in different places,
6. seek to murder the plants.

Before we look at these approaches let's look at the basic ecology of a lighted cave. Plants need light – we have provided that with our electric lighting systems. Intensity and placement are important here. The duration of the light is determined by the way we run our cave tours and whether our guides switch things off – or whether we have set up the system so human error is reduced. Using sensors, time switches or fading techniques can manipulate light supply.

Plants need something to grow on – porous, chalky surfaces provide better environments for plant establishment. But any surface will support life if light and water are available. So direct our lights onto surfaces more inimical to plant growth. Wow! Plants need water. How about shining our lights on the dryer parts of our caves!

Plants need nutrients. Not something that is very pertinent to our *lampenflora* problem – but reducing lint, skin flakes or dust loadings, whilst nearly impossible, might help a bit.

So operating a show cave provides all the things we need to grow plants…

As Nell Kell points out:
Certainly light selection and placement plays a role in lampenflora, however from my many weeks of wandering around inside functioning tourist caves and observing the operation of the lighting by guiding staff, I have to say that I suspect the use of the lighting may be a larger contributor to lampenflora than we expect. This is not entirely the fault of the guides as they can only do their best with what system is in place… But I have observed common overuse of lighting, leaving lights on when they are not needed, and forgetting to turn lighting off. The larger factor in all this is the design of the cave lighting to be an efficient user of energy to achieve the lighting aims within the constraints, and the design of the use of the lighting to reduce the inefficiencies that arise within its use.

Elery agrees:
I have come to the conclusion after lots of discussion and experiment that lampenflora is an indicator of inappropriate lighting practices.

As does Ian Houshold:
Lampenflora growth rates have plummeted since Neil installed his new lights here (in Newdegate Cave, Hastings) *– any serious attack on cave plants should begin with re-thinking lighting strategies.*

It is worthwhile to reproduce Steve Reilly's Jenolan experiences at length:

I enclose some general observations of lampenflora and strategies we are using to limit lampenflora growth at Jenolan. With the recent relighting of a number of our caves we looked at reducing lampenflora in the planning stages.

We purchased a good incident light meter and have been looking at what light levels (and other factors) are causing lampenflora. In a couple of clay sediment areas where there were bright lights you can see that lampenflora extends out from green to white and there is obviously a succession of different types of growth from the strongest light point outwards. I suspect that growth around a light (even at a point where growth is not visible) extends far beyond the visible patch of green in most cases.

I know the above is obvious, but it's a good point that lampenflora and different types of flora often extend way beyond the green blob in front of a light.

More than 200 incident light meter readings that were taken in a number of caves suggest the following:

If you put bright light onto a wet surface the lampenflora will invade.

The main elements observed for the growth of the main visible lampenflora infestations were moisture present most of the time, lights on for longer duration and the type and texture of the surface (i.e. clays and dirty rough rock/crystal promote growth).

Obviously light intensity was required for growth, however most of the most intense light readings in the caves on dry rock had no growth. Even on moist areas if the lights were only on for a few minutes every day there was often no visible growth.

The work with the incident light meter was not done as part of a well-documented study. I talked to Tom Aley about work he did to obtain thresholds for recommended light levels for lampenflora in a couple of caves, but we do not have the time to do that and a drought is not a good time to do the study.

The strategies we have used to relight caves based on the above and energy efficiency and cost savings include:

- *not directing high light levels onto wet areas, cave walls or any surface.*
- *use of C-Bus programmable light control systems. This has allowed us to reduce the time lights are on dramatically. We can time every light to turn off when we want; we can turn off large sections of lights and this stops lights being left on accidentally.*
- *use of lights with superior reflectors*
- *use of dichroic, LED and fluorescent lights and a range of efficient lamps.*

In the redeveloped Lucas cave we have halved the wattage that was in place in the old lighting.

Other benefits of programmable lighting systems include:

- *the system can also record the amount of time lights are on*
- *the ability to set all lights(except fluorescents) to dim up to 95% capacity and this increases lamp life significantly*
- *we can program the lighting in the office, ensure lights are not left on and track where guides are if needed as I have installed optic fibre from the caves to the Guides Office*
- *the system can also collect data from probes or instruments in the cave at numerous points*
- *the system has allowed us to remove kilometres of light cables now that they do not have to be wired directly to a switch. We run cables the shortest distance from the mains we can design and the C-bus switches them on from wherever.*

As an add-on to my earlier email. We are taking the view that the treatment of lampenflora with chemicals on an ongoing basis is not a solution for anything. Chemicals (chlorine) may damage caves, their contents and science will probably indicate they are bad for humans more then thought.

We must light caves and switch on lighting for durations that stops or almost completely limits lampenflora growth. This should be everyone's aim. Many caves I have visited could spend a year just shifting lights away from wet areas and this would dramatically reduce lampenflora in them.

It could be worse. Thank God I am lighting temperate caves and not those located in the tropics!

Now let's revisit the ways to solve the problems I identified above. Let's look at each of them in turn:

1. Turning off the lights. Makes showing the cave pretty awkward… whilst all you bureaucrats may be in the dark the public won't like it, the guides will be unhappy and there are obvious OH & S implications. And it might not work very well anyway. In 1984, Yarrangobilly Caves lost its power system from April until December. The *lampenflora* in the Glory Hole Cave blackened but did not die. Once the lights came on again the green came back.

2. One way of reducing our *lampenflora* problems is to reduce light intensity and duration. We

should all do this immediately – consistent with effectively showing the cave and providing enough light to avoid OH & S problems. But this will only slow the invasion and occupation as indicated above.

3. Change the lights. An obvious approach. Plants have an active response to the light spectrum as the various light-using pigments respond to different parts of the electromagnetic spectrum – this is called photosynthesis and is the basis for most life on this planet. Let's screen out the wavelengths that plants use, but humans can still use for vision! Easy – problem solved! Unfortunately the human light response spectrum and the photosynthetically active wavelengths are much the same! Black for plants = black for cave visitors!

Flowstone heavily infested with lampenflora

Dave Williams comments:
Until recent times most caves were over lit and the lighting was left on often when it was not needed. Lampenflora on any surface is a product of light intensity (or amount) and duration providing there is adequate water and there usually is. We have greatly reduced the lampenflora problem at Waitomo by reducing both the intensity of light and the duration. I believe this principle is incorporated into most new cave lighting plans these days.

In the late 1970s there was some work done in Waitomo on the wavelength of light with the hope that they could find a band of wavelengths that gave good human vision but did not encourage photosynthesis. It was very interesting work but in the end they concluded that because plants and the human eye had both evolved to use that band of abundant light energy in what we know is the visible light spectrum they would not find an incompatible band of wave lengths. They also tried ultra-violet light as an algaecide and had some good results but in the end they recommended calcium hypochlorite as the simplest and most effective method.

I still think UV light could be used on the ingrained lampenflora, so this is another method for someone to test.

Another possible way to prevent lampenflora is to have two parallel lighting placements within the cave with one being rested for say 6 months to kill off any plants that had germinated.

4. Perhaps we could change the light sources to suppress or reduce plant growth? This is a variant on point 3 above. We can certainly use different light sources to reduce *lampenflora*.

Steve Reilly notes:
We have replaced hundreds of lights in the last four years and staff have noticed the following in regard to old and new lighting systems:

- *normal daylight fluorescent lights (compact and 4 footers) promote growth.*
- *limited spectrum fluorescent lights (many different types and brands) appear to inhibit growth well.*
- *the old incandescent bulbs are terrible and most growth relates to them(often because they are close to walls or the floor.)*

5. How about a dual lighting system using ultraviolet (UV) sources to kill or suppress *lampenflora* at night when the cave is not being use? Certainly feasible but expensive if two lighting systems are to be installed and a potential hazard with UV damage to eyes if the system fails or if there is after hours use by staff or visitors. Such an approach may also encourage those inefficient or bad practices that Neil referred to above.

6. Murder will out… Before going on here I must emphasise that chemical methods will merely treat the symptoms of our disease (as do points 2 to 5 above!) – the problem will still be there, will require follow-up treatments for the rest of time and may promulgate bad lighting practice!

If we are going to use chemical methods I believe that we might have two choices:

- We might use simple inorganic chemicals such as the powerful oxidising sodium or calcium hypochlorite that we are used to using – or hydrogen peroxide that we talk about but never seem to evaluate.
- Or we might use more complex organic herbicides such as Simazine, Diquat or Diruon.

Let's look at the latter class first.

Dr. Grant Gartrell offers the following comments:
I have no experience in lampenflora control whatsoever beyond turning out the lights. However, as a horticulturalist, I am aware of a range of selective herbicides used to attack weeds, which grow in other circumstances.

There are some herbicides that basically "Nuke" everything in sight, and others that have a much smarter action, e.g. in only attacking a part of the growing process involving chlorophyll, in other words only working on green plant tissue.

There are also some herbicides that have long residual life, but simply prevent germination of seeds, thereby suppressing regrowth once the initial infestation has been neutralised and cleaned up. I don't know whether any of these would be effective against the germination of spores which initiate lampenflora, but most of these things would be applied as a simple spray about once a year, would be virtually undetectable, and would very likely have just about no impact on the cave biology beyond their specific purpose. Whether anyone has conducted research along these lines I do not know, but if no other satisfactory solution is forthcoming, a little research along these lines would be relatively simple to conduct, and might be interesting?

Simazine is applied as a wettable powder that binds to the top six inches of soil, requiring rain to wash it into the soil and achieve the result, and presumably its presence in small amounts on the surface of limestone adjacent to a lamp would have a similar effect, combining with the humidity in the cave which would also be needed to encourage germination. There are a number of other formulations, which have similar action.

Rauleigh Webb has summarised the results of work by Johnson (1979) at Waitomo as follows:

Herbicide	***Concentration***	***Effect***	***Ttime***
Diquat	*0.11%*	*None*	-
Diruon	*0.14%*	*None*	-
Sodium borate	*1%*	*100% kill*	*in weeks*
Sodium hypochlorite	*2%*	*50% kill*	*within hours*
Calcium hypochlorite	*2%*	*90% kill*	*within hours*

Note that the first two are organic herbicides (and may or may not be designed to act on lower plants – algae, fungi, mosses or ferns!). The latter two are powerful oxidizing agents, which we will discuss in far more detail in the next ANDYSEZ – together with hydrogen peroxide. Sodium borate is a chemical used for timber treatments against algae and mosses in moist environments and in my experience they can be very effective. However, neither the companies which market this and related compounds can (or will?) tell me anything about any potential environmental effects. Indeed, the Commonwealth regulatory authority assures me that these boron compounds are 'environmentally benign'. But it kills living things? There may seem to simple souls like me that there is a problem here… Recall Swabey and Roest's paper on chromated copper arsenic (CCA - 'Koppers') timber treatments at the last ACKMA conference – and the various Environmental Protection Authorities' concerns around Australia (and NZ?) that are emerging.

Clearly there are many opportunities for further investigation of organic herbicides – including looking at those designed or directed at lower plants, which often have totally different biochemical pathways and cycles to higher plants. But we don't know much about them – or any breakdown products or their potential effects on cave animals (and bacteria and so on…).

The next ANDYSEZ will look at chemical agents in more detail and provide some recipes for their application – but I fear that many questions will be raised therein – as usual!

In a late communication from Ian Houshold the following is of sobering significance:

The more I read and see the more I realise that bacteria are likely to form an important base to food chains in caves, particularly those with large areas of moonmilk or sulphides in the bedrock/sediment substrate. A wonderful relict troglobitic phreatoicid isopod 'swarm' in a high level rimpool at Marakoopa Cave, Mole Creek, seems to be entirely reliant for food on what drops off the moonmilk above. Anything that disrupts microbiological processes should be weighed against other factors. At this stage peroxide does not look good for the microbugs (as do some proposals I have read to 'sterilise' plant growth in caves with high strength uv light).

In conclusion we had an email asking how to grow *lampenflora*! Lana Little says:

Andy, I'm pleased to report that to date we at Chillagoe have had little need to concoct anti-lampenflora recipes. But... does anyone have recipes to promote algal growth? I need to develop an action plan to address the issue of graffiti at the Archways. Removal of some of the graffiti would involve destruction or disturbance of otherwise attractive green algal coverings on limestone walls. I'd love to be able to restore the algae as quickly as possible following the graffiti removal. There might be some landscapers out there that know how to make translocated rocks settle into their new surroundings more rapidly by sprouting a coat of mosses, lichens or algae??

Well – two sides to every coin! Obviously the provision of light and water will help – if difficult to achieve at Mungana! At least some of the time… An perhaps some extra nutrient might help – a nice simple organic substance such as the effluviae of bats or cows which might well be found around *The Archways* applied as a dilute suspension in water might help. Any other ideas from ACKMAland to help Lana?

REFERENCES

Johnson K, 1979, Control of Lampenflora at Waitomo Caves, New Zealand, Cave Management in Australasia III, Proceedings of the 3rd Australasian Cave Tourism and Management Conference, 3:105-122 (on ACKMA web site under 'Hot Topics').

Swabey, S and Roest, M, 2003, Chromated copper arsenate treated wood in caves, Cave Management in Australasia XV – 15th *ACKMA Conference Proceedings*, Chillagoe/Undara (in press).