Fire, Rain and Pestilence; not always positive for Jillabenan Cave, Yarrangobilly

John Brush

Canberra Speleological Society Inc

Email: Warwillah@gmail.com

Abstract

Jillabenan Cave is the smallest and arguably the most extensively decorated show cave at Yarrangobilly in the Kosciuszko National Park, New South Wales (NSW). *Water underground*, the theme of this conference, was essential for the formation and development of Jillabenan, which is a fossil stream cave. The erosive powers of water carved out its passages and deposited sediments. Water was also the vehicle for enabling the growth of the extensive and varied speleothem displays for which the cave has been justifiably famous since it opened as a show cave within three years of its discovery in 1910. The speleothems, which would have originally come close to blocking the main passage, would have presented challenges for early explorers and for the workers who extensively modified the cave for visitor access. At first, deep trenches for a pathway were cut into the flowstone floor, stalactites and stalagmites were removed and 'protective' barriers were installed. Later, concrete paths were laid and electric lighting was installed. Even after the cave opened to visitors in 1913, speleothems have been damaged accidentally, or intentionally, during maintenance activities, by visitors on cave tours and during scientific research projects. More recently, bushfires, Covid-19 response measures, visitation pressures, staffing issues and rodents, coupled with several seasons of above-average rainfall, have adversely impacted the cave, either directly or indirectly, and presented a range of management challenges. This paper focuses on some of the recent impacts on the cave and reviews the remedial measures put in place.

Introduction

Jillabenan Cave is a guided show cave in the Yarrangobilly karst area of the Kosciuszko National Park, NSW. It is a fossil stream cave that has almost 200 metres of passage, nearly half of which has been equipped with lighting and concrete pathways. The cave is highly decorated with a spectacular range of calcite speleothems.

It was discovered in 1910 after a narrow tube was sufficiently enlarged to permit human access. The significance of the find was immediately recognised and, after substantial works had been carried out, the cave was opened for public inspections in 1913 (Trickett, 1914), prior to its official opening the following year (Hoad, 2004, p75).

As Jillabenan lies close to the surface, its active speleothems respond relatively quickly to outside rain events and its temperature range is wider than in some of the other caves in the area.

The cave has only one entrance, restricted air movement and relatively modest passage dimensions. The passages are generally less than three metres high and wide, except near the end of the pathway where the main chamber is about twelve metres wide and four metres high, as well as having an eight-metre-deep pit on one side.

As Oliver Trickett so eloquently reported after his first visit to the cave in 1910 (Trickett, 1911), Jillabenan Cave "may be shortly described as consisting of a superb central cavern, with highly decorated but somewhat narrow passages at either end. On the way are seen *mysteries* - those wonderful lime sprays which twist and curl into fantastic shapes, glistening white and tinted stalactites descending from fleecy-like bases, and dainty grottoes curtained and floored with coral-like dripstones. At 160 feet, a glorious cavern is ushered in under a series of canopies. There is very little in the caves which have been termed *The Wonderland of New South Wales*, to surpass the loveliness of this cavern."

Partly because of its spectacular decoration Jillabenan Cave is very popular with visitors. But it also has very easy access. The entrance is just 150m from a car park and the short pathway through the cave has a gentle gradient. In fact, it is one of the few wheelchair-accessible caves in Australia.

A brief history of the area

Long before Europeans first visited the Yarrangobilly valley around 1840, the area was known to Aboriginal people. Three kilometres north of Jillabenan, investigations have found evidence of intermittent use of a small cave between 9700 and 9120 years ago (Aplin et al., 2010).

The first caretaker, James Murray, was officially appointed in 1887, but for several years before that,

he and other locals had been taking interested visitors into the Glory Hole Caves. The first accommodation cottage for visitors was built in 1888, a second cottage and a telephone line to Kiandra, the nearest town, were completed in 1890. Visitors were first shown into Jersey and Harrie Wood Caves in 1892 and into Castle Cave around 1895. Road access into the area was completed in 1894. In 1901, a major new accommodation building, Caves House, was built and came into full operation as furniture was acquired during 1902 and 1903.

By the time Jillabenan Cave was discovered in 1910, the Yarrangobilly area was a well-known attraction and the other five show caves had been open for public inspections for at least 15 years.

The cave's potential as a show cave was immediately recognised, despite the challenges presented by its small entrance hole (Hoad, 2004, p86) and modest passage dimensions (Trickett, 1911).

Modifications to Jillabenan to facilitate public access

Access and constructing the tour route

Jillabenan Cave has been substantially modified to enable safe and easy public access. During 1911, there were excavations to open the entrance (Pittman, 1912), followed by some "very heavy rock cutting" (Trickett, 1913), as evidenced by the trench cut into the flowstone floor. In places, the cut is more than a metre deep (Figure 1). Iron posts, handrails, and wire netting to protect cave features were also installed by 1926 (Bilton, 2010). Some of the iron posts can still be seen in the cave today.

In 1967-68, the pathways and handrails were upgraded as part of a major infrastructure redevelopment project commissioned by the National Parks and Wildlife Service of New South Wales (NPWS). The work was done by prisoners during a period when the show caves area operated as a low-security outpost of Cooma Jail and the area was closed to the general public.

Figure 1: Trench cut into flowstone

The pathways were again modified in 1989-90 to make the cave wheelchair-accessible. This involved replacing steps near the entrance with an inclined path, installing a rudimentary ramp above another set of steps, widening the concrete pathway, and adding raised edges to it. The trench cut into the calcite floor was also widened in several places and a large chunk was sliced off a calcite column.

Cave Lighting

Initially, cave tours were illuminated by candle light, followed by battery-powered torches after the first World War (Bilton, 2010). Guides also used magnesium lamps (Trickett, 1917). One of these lamps can still be seen at Yarrangobilly. It has a clockwork mechanism to feed magnesium ribbon at a steady rate through a small tube to the centre of a reflector where it was burnt. This produced a very intense white light. However, it also produced clouds of white smoke that settled on cave surfaces as a white or pale grey residue, traces of which are still visible today.

Yarrangobilly was never connected to the NSW power grid. On-site generation commenced in 1920 when a small kerosene-fuelled generator was installed to provide lighting in Caves House. In 1926, generating capacity was substantially upgraded after construction of a small hydro plant (Bilton, 2010) and a concrete dam on Rules Creek (Hoad, 2004, p95). It then became feasible to light the caves. For Jillabenan, this happened by the end of 1926 (Bilton, 2010).

The original cave lighting system in Jillabenan was replaced in 1967-68 by the prison workforce (Bilton, 2010).

The lighting was again replaced in 1989 (Bilton, 2010). The new system included very bright PAR38 floodlights. Lampenflora risks were managed by carefully siting and aiming the lights, limiting the

number of daily tours and, from 1992, systematically recording lampenflora locations and promptly treating any outbreaks.

Guided tours into the cave

Visitor numbers

As noted above, Jillabenan tours commenced in 1913. By the early 1920s, the cave was attracting more than a thousand visitors a year, according to Bilton (2010), a former guide at Yarrangobilly who was able to compile visitation statistics between 1921 and 2009 from records held at the caves. The records are incomplete, but show that by the late 1920s, annual visitor numbers were approaching 3000 but fell to less than 1000 a year during the Second World War. In the early 1960s, annual totals varied from 3700 to more than 6000 a year. Between 1989 and 2009, visitor numbers averaged 3400 a year, but reached a maximum of 6300 in 1991 when Jersey Cave was closed for refurbishment.

The number of visitors in a year is a useful indicator of likely unintentional visitor impacts on a show cave, such as the accumulation of lint, dust/mud, and organic matter. Lint comprises fragments of clothing fibres, human hair and skin fragments that are shed as visitors move through a cave. Dirt and organic matter are tracked into (and around) a cave on the footwear of visitors. Accumulations of lint and dirt dull speleothem surfaces and can become incorporated into them and are also potential nutrient sources for microbes.

From a cave management perspective, it is at least equally important to have regard to (a) the number of tours each day, (b) the tour duration and (c) the maximum group size. The number of tours and their duration provides a measure of the amount of time the lights are likely to be switched on each day. The group size impacts on the experience for each visitor and on the ability of the guide to conduct an effective tour while at the same time managing the integrity of the cave. Such issues are particularly important in a small cave like Jillabenan.

Daily tours

Locating historical records on the number of daily tours is difficult. A photograph of a sign that stood outside the ticket office in 1969 shows there was provision for up to 4 tours a day into Jillabenan. Many brochures on the caves produced by NPWS in the 1970s through to the 2010s stated there were three, four or six tour times each day without providing any information on the number of tours into any specific cave. However, anecdotal comments made by several former managers suggest that a common approach was to conduct one or two tours into Jillabenan each day, rising to three or four tours a day during the summer months and over busy long weekends.

Tour duration

Information in the above-mentioned NPWS brochures indicates Jillabenan tours were between 60 and 75 minutes long.

Party size

The physical characteristics of Jillabenan limit the number of visitors than can be comfortably accommodated on a tour. Because of the narrow pathways, visitors can only move through the cave in single file and there are only two places where there is space for a group to assemble to and interact with the guide.

Records of the maximum permitted size of a group are difficult to locate. A photograph of an 'old' notice, most likely dating from the 1960s or 1970s indicates a maximum of 15 visitors. Since that time, it seems it was generally accepted that the maximum number that was manageable for a guide, but also resulted in positive experiences for visitors was 15 or 16 people. However, Bilton (2010), citing records held at the caves, states that the largest group recorded for the cave was 38 visitors in January 1964. There have also been occasions where full bus-loads of people have been split into two groups then taken into the cave on consecutive tours, suggesting group sizes of around 20 people. It is for this reason, perhaps, that in the Karst Area Plan of Management for the Kosciuszko National Park (Anon, 2015), the group size limit was set at 20 persons.

Cave cleaning and maintenance

According to Colin Hoad, "the cave formations, particularly in the Jersey and Jillabenan caves were completely washed at least once during the winter months" (Hoad, 2004, p78). The timeframe for this broad statement is not stated, but it appears in a chapter covering the Leo Hoad era (1907 to 1946). According to Bilton, systematic recording of cleaning locations and activities did not commence until 1992. This methodical approach focussed on lampenflora and continued through to at least 2010 (Bilton, 2010). Bilton also notes there was a comprehensive clean-up of the cave, including removing rubbish from the Alligator and Bottomless Pits that was undertaken with the assistance of caving groups in 1999. According to former staff, the regular cleaning of cave pathways and some flowstone areas with water

and a wet-dry vacuum, was discontinued in the mid-2010s, but some *ad hoc* lampenflora control work was continued by individual staff members. Another staff member who commenced duties after that time noted there was no readily accessible documentation in the office on cave cleaning and maintenance schedules or procedures, or any records of work that had previously been carried out to help them come up to speed. It seems the earlier records may have been discarded, or perhaps buried in one of the many unlabelled archive boxes stored in a shed.

The Bath of Venus/wishing well

An early example of water not being a positive force in Jillabenan occurred in the Bath of Venus in the 1920s. An unlabelled photograph in the office records at Yarrangobilly Caves, shows sub-surface areas of the pool as having finely sculptured coralline sides and a convoluted deep section in the centre. Bilton (2010) believes the photograph was taken by Leo Hoad before 1926 (Figure 2). Another photograph, labelled on the image as a Leo Hoad photograph, shows that by 1928*, the pool had become a 'wishing well' with a uniformly shallow bottom (Figure 3). According to Bilton, visitors were encouraged to throw coins in and make a wish, and the pool was filled in to facilitate the collection of coins, which were donated to Tumut Hospital (Bilton, 2010).

*This date comes from a letter sent to Yarrangobilly Caves in the early 2010s. The letter-writer said their parents visited the caves on their honeymoon in 1928 and enclosed 8 photographs from the trip, including four Leo Hoad photographs of Jillabenan, one of which is a view of the pool showing the modified bottom and an accumulation of coins. [The letter and photos were inspected and photographed by the author in 2013].

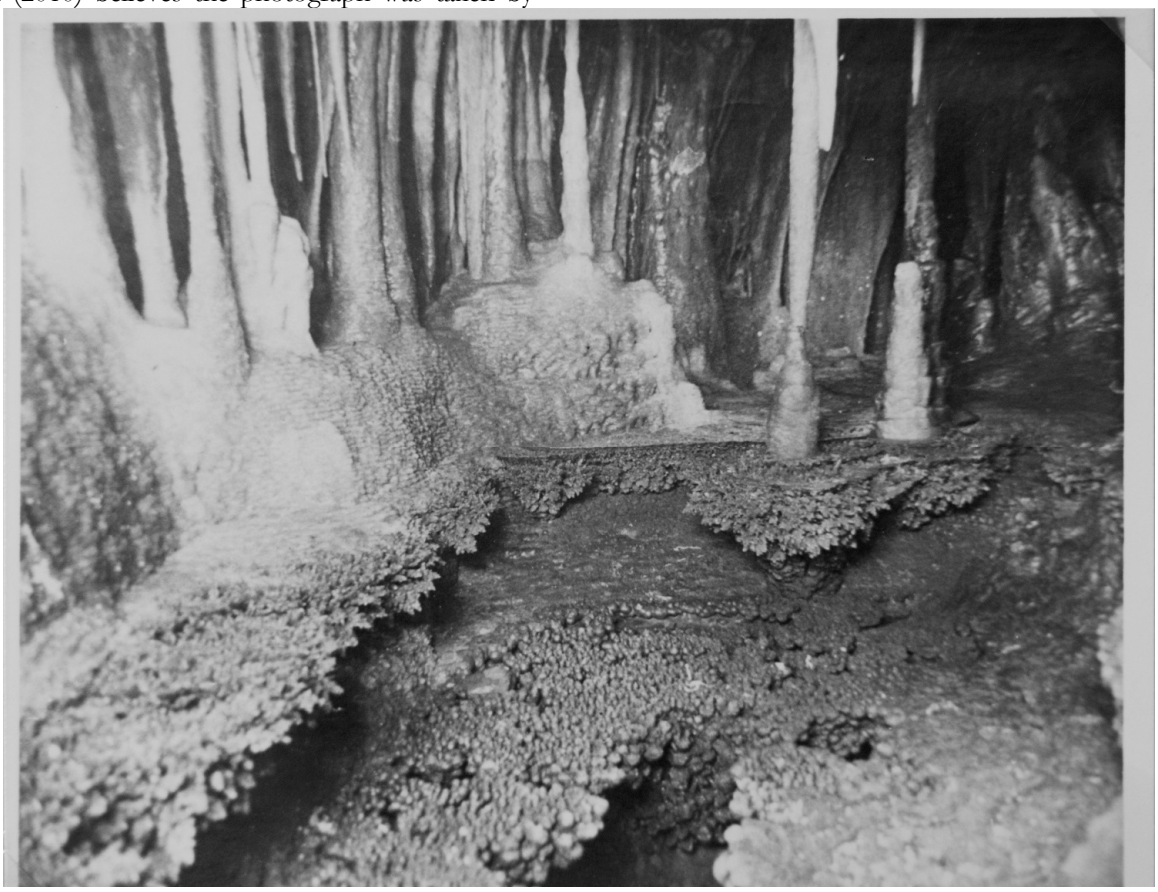

Figure 2: Pre-1926 photograph of the Bath of Venus

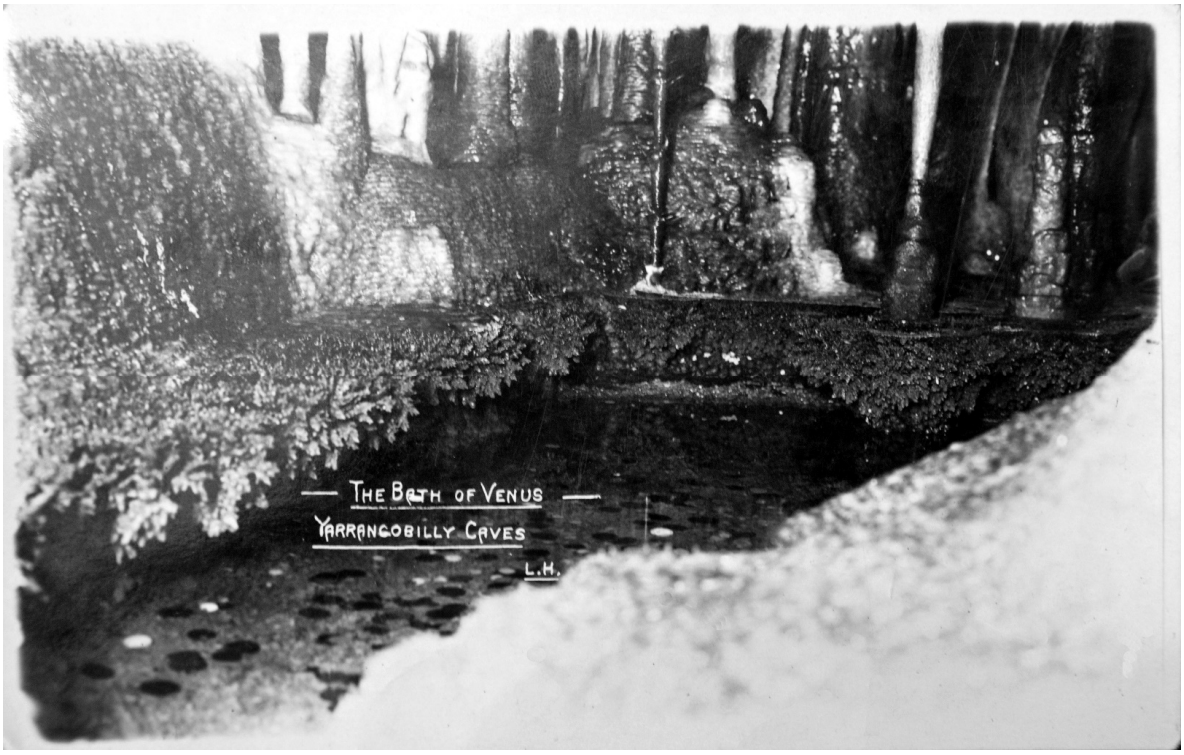

Figure 3: Photograph of the Bath of Venus, circa 1928

The alterations diminished the aesthetic values of the pool and the coins caused blue-green copper stains that are still visible today. The pool continues to be a management issue as some visitors still want to throw coins in, even though the activity was banned several decades ago.

It could be argued that if the original pool of water had not been there, it is highly unlikely the wishing well would have been built, leading to the conclusion that water was indirectly responsible for the wishing well and consequent impacts and the ongoing management issues.

Fire, rain and pestilence in the early 2020s

A more serious case of water not being a positive force for Jillabenan occurred in the early 2020s when the effects of three unlinked events combined and resulted in significant impacts on the cave.

In January 2020, major bushfires burnt most of the Kosciuszko National Park, including virtually the whole of the Yarrangobilly karst area. Caves House and all major buildings were saved, but there was severe damage to other surface infrastructure, including roads, the power system, water supply and visitor facilities.

In the months following the fire, precipitation was above-average and there were some severe storms. While the rain facilitated early regeneration of the bush (Figure 4), the flush of water from storms resulted in washaways, slope stability concerns and considerable movement of sediments and ash along watercourses and into several caves.

Figure 4: The January 2020 bushfire severely burnt vegetation across nearly all of the Yarrangobilly karst, but above-average rainfall in the months following the fire facilitated early regeneration (Photograph taken in May 2020)

The whole of the Yarrangobilly area was closed while repairs and safety assessments were carried out. In July 2020, NPWS reopened surface facilities to the public, but some restrictions remained in place because of the risks posed by burnt trees and loose rocks that no longer had vegetation and soil to hold them in place.

Meanwhile, the Covid-19 pandemic had become a serious public health issue across Australia. There were lockdowns and travel restrictions. In NSW, the government closed access to all caves in national parks, including show caves.

In November 2020, Jillabenan was the first cave to be reopened to the public. NPWS considered that as Jillabenan was the smallest show cave in the area, it was the only one where it was feasible to implement the Covid-safe requirements of the NSW Government. That Jillabenan was an 'easy' cave and therefore catered to the broadest spectrum of visitors also appeared to have been a consideration.

To comply with the government requirements, handrails (in theory, the only surface in the cave touched by visitors) were cleaned regularly, hand sanitiser was dispensed to everyone as they entered the cave, the maximum group size was reduced from 16 to 12 and everyone was requested to maintain social-distancing. In addition, the duration of tours was reduced to 45 minutes.

As Covid restrictions eased, there was pent-up demand, and visitor numbers at Yarrangobilly soared. To cater to the demand for cave visits, the number of tours to Jillabenan was increased from the off-season norm of two, to four each a day. In December 2020, self-guiding tours through Glory Cave re-commenced but as visitor numbers continued to rise, it became necessary to further increase Jillabenan tours to as many as eight or nine on the busiest days during the January 2021 school holidays.

By the end of the end of the summer holidays, around 17,000 visits into the two re-opened caves had been recorded. Staff had also noticed some changes in the cave.

What was happening to Jillabenan Cave?

Early in February 2021, guiding staff noticed a black discolouration in places where visitors inadvertently touched calcite speleothems (Figure 5). Visitors are instructed not to touch anything in the cave other than the handrails, but there are several places where visitors commonly place their hands for support as they pass two low-roofed sections, climb four steps into the Crystal Grotto, and lean forward to get better views of the Crystal Grotto and the Bath of Venus

As these touching points had been stained brown for many years, but had turned black, guides concluded that the hand sanitiser must be responsible as it was the only factor that appeared to have changed.

Figure 5: A stalagmite near the Bath of Venus that is commonly touched by visitors and showing black microbial growths that appeared in early 2021

By the end of February, guides noticed other changes, including that the black discolouration, had appeared on speleothems beyond the reach of visitors. Despite the staff concerns, no action was taken to address the changes observed in the cave. However, as the Kosciuszko Speleological Reference Group (KSRG) was due to meet in the area the following month, an inspection visit to Jillabenan was arranged. KSRG is a consultative advisory group established in 2011 to assist NPWS in identifying, assessing and managing speleological issues in the Kosciuszko National Park.

Observations in the cave in March and April 2021

The four speleo members of KSRG visited the developed part of Jillabenan Cave with NPWS staff on 29 March 2021. Each of the KSRG members, including the author of this paper, had different backgrounds and cave-related experiences. None of them had any cave microbe expertise, but did have a reasonable understanding of management issues in show caves, including in relation to lampenflora. Two KSRG members returned to the cave in mid-April for another inspection visit prior to undertaking cleaning work.

KSRG's observations:

- A strong musty odour was obvious in the first 10 metres of passage. Staff reported the odour was stronger than they had noticed in the past;
- Aggregations of black splotches that had the appearance of black mould, occurred in several areas, including sites touched by visitors and on several actively growing speleothems, as had been reported by staff. There were also black

growths on several dry-looking speleothems, on remnant sediment banks, and on areas of bare bedrock wall;

- Green lampenflora on microgours in the main chamber and beside the Bath of Venus;
- Brown to yellow-orange coloured slimy or filmy blooms (algae or possibly cyanobacteria) where water had ponded, such as in, and on the floor below, the Bath of Venus, in runoff areas beside the concrete path, in microgours and other depressions in flowstone. They were most prominent in brightly-lit areas;
- The water in the Bath of Venus was discoloured and cloudy-looking. Dead blowflies were decomposing in and on the water. Springtails (Order Collembola), a feature that guides often pointed out to visitors were not visible, and staff had reported not seeing them for some time;
- Rat droppings were common throughout the cave but were more numerous in the outer parts. In damp areas, the pellets had fungal growths on which sporangia could be seen.
- Blowflies (alive and dead) were common throughout the cave. According to one of the guides, they were considerably more numerous than in previous summers and appeared to follow visitors into the cave where many of them remained until they died. Close inspection of dead flies in wet areas revealed pupae and maggots on them, indicating flies were breeding in the cave;
- Both rat droppings and dead blowflies were decomposing in the wet areas and were staining actively-growing flowstone and were becoming incorporated into it;
- Accumulations of dirt and organic matter on pathways and areas draining from the paths; probably tracked in on footwear of visitors; and
- Lint accumulations on many surfaces were becoming incorporated into actively growing speleothems.

Possible explanations for the changes observed in the cave

Increased visitor numbers

Even though tour group size was reduced from 16 to 12 over the 2020-21 summer season, the maximum potential visitor load would have been 96 visitors a day, a 200% increase over the normal off-season maximum of 32 a day and a 50% increase on the normal summer maximum of 64 a day. More visitors result in more dirt and lint being introduced to the cave, both of which are potential nutrient sources for microbes. Dirt and lint can also dull and discolour speleothem displays.

Increased number of daily tours.

The duration of a cave tour had been reduced from the usual 60 minutes to 45 minutes, but as there were more tours, there was a considerable increase in the number of hours that lights were illuminated each day. In the off-season, the lights would have been on for no more than two hours a day and a maximum of four hours a day in summer. But with eight trips, the lights were probably on for six hours each day, or seven hours on the busiest days when nine tours were conducted. To accommodate eight or nine tours a day, the trips were essentially run back-to-back and comments made by staff suggest the lights were not always switched off between tours. This suggests the cave interior could have been continuously illuminated for six or seven hours each day for several months, thus significantly increasing the likelihood of lampenflora developing, especially in areas lit by floodlights. The high level of visitation exposed the limitations of the 1989 lighting system and the 1992 lampenflora management strategy, under which it was assumed the floodlights would be illuminated for only brief periods, that there would be a maximum of four trips a day over the summer months and that any lampenflora outbreaks would be promptly treated. Moreover, as some of the lights installed in 1989 had fittings that could be swivelled and tilted, it is possible their orientation may have been unintentionally altered while replacing burnt-out bulbs, resulting in more intense illumination on nearby surfaces and thus increasing the potential for lampenflora.

While increases in the duration and intensity of illumination help to explain the lampenflora blooms, it cannot account for the sudden appearance of other microbes, such as fungi and moulds, that are not dependent on light.

Hand sanitiser

Over the 2020-21 summer season, all visitors were required to use hand sanitiser gel, leading to the initial conclusion of guiding staff that it must have been responsible for the black discolouration on speleothems that had been touched by visitors. The gel used at Yarrangobilly was either a mix of methylated spirits and glycerol made up by a local compounding chemist, or a packaged supermarket product that contained either glycerol or aloe vera as the gelling agent. Both glycerol and aloe vera can have anti-microbial properties. However, given the strong correlation reported by staff between the first appearance of black growths and the places that

visitors most commonly touch, there must be other factors at play. At low concentrations, glycerol loses its anti-microbial properties. It also leaves a greasy residue that may bind other substances, such as dust or lint, to cave surfaces which then become a growth medium. It has also been suggested that as glycerol is hydrophilic, the moisture absorbed may facilitate the growth of moulds. However, the gel appears unlikely to be the major reason for the black blooms. A simpler explanation may be the influx of nutrients from bushfire ash and the splotches in question were noticed first simply because they were much closer to the visitor pathway.

Soluble compounds in bushfire ash

As noted above, black microbial blooms were observed on a variety of substrates in locations throughout the cave, including on active speleothems, on speleothems that appeared to be dry, on sediments and on bare rock. Based on drip water studies at Yarrangobilly over several years, Professor Andy Baker suggested (pers. comm., 2021) the blooms most likely result from mobilisation of soluble components in ash from the 2020 bushfire seeping into the cave in percolation waters and increasing nutrient availability in the cave.

Issues with the cave door

The steel door at the cave entrance is closely fitted but not air tight. The gaps are large enough for cave crickets to pass in and out, but are small enough to exclude mammals and most rodents. Nevertheless, there are reasonable explanations for the presence of blowflies and rats (or rat droppings) in the cave.

The usual practice for cave guides was to open the door before making introductory comments and subsequently entering the cave. It was not uncommon for the odd fly to follow visitors into the cave during summer. In 2020-21, with the increased number of trips, there were more visitors and the door was opened more frequently each day. It was also open for longer periods as visitors were required to apply hand sanitiser gel, which was kept just inside the door. Comments by staff suggested that on busy days, when tours were almost back-to-back, the door was left open between trips. It is also likely that the wet spring and summer, also provided favourable breeding conditions for flies; there were simply more of them in the area. Taken together, these factors probably account for the increased number of blowflies in the cave.

For some years there has been a hole in the sheet metal surrounds of the cave door. The origin and purpose of the hole is not known. It is several centimetres in diameter and a close inspection reveals it has a stained trail leading to it on either side of the door. This hole appears to be the most likely access point for the rodents responsible for the pellets scattered through the cave. With a view to capturing some for identification purposes, staff placed Elliott traps in the cave during the latter half of 2021. The only species captured was the black rat (*Rattus rattus*), a discovery that may help guide future control strategies if blocking the hole is not effective.

Access to management information, maintenance records and training resources

Discussions with staff in April 2021 suggested there was a paucity of readily available information at the caves on local cave management procedures and cave cleaning records. The discussions also revealed some staff may not have fully appreciated the implications of leaving the cave lights illuminated for many hours at a time, leaving the cave door open for extended periods, or of the appearance of microbe colonies in the cave, suggesting also there may have been challenges in accessing relevant training resources.

As some of these procedures and records once did exist (Bilton, 2010), it raises the question of whether the records have been discarded or misplaced. Considered in conjunction with the earlier staff comments about the demise of regular cave cleaning activities, it raises the question of whether there had been a gradual erosion of office clerical procedures and cave maintenance activities over the decade leading up to the 2020-21 season. This period roughly coincides with the staged re-opening of Caves House in 2007 (1901 building) and 2013 (1917 building), suggesting that staffing priorities may have been progressively redirected towards servicing the accommodation facilities. In other words, a shift from good house-keeping in the office and the caves, to the accommodation buildings. The author is not in a position to know the extent to which this may have occurred.

It seems likely that local staffing issues contributed to some of the impacts observed in the cave.

Addressing the impacts

After the inspection visit, KSRG prepared a report for NPWS on its observations, along with supporting photographs and around 20 recommendations. Some of the recommendations were proposed as immediate priorities for addressing the observed impacts while others were aimed at implementing changes to reduce the likelihood of recurrences in the future.

NPWS accepted the recommendations and promptly initiated appropriate actions to implement most of them.

In mid-April 2021, two weeks after KSRG's initial inspection, three cavers (two of them KSRG members) along with a varying number of NPWS staff, undertook a comprehensive clean-up of the cave. Over a four-day period, most of the illuminated part of the cave was swept, brushed, scrubbed and washed with clean water, as needed (Figure 6). Some of the black mould and brown algae (or bacteria) were removed by scrubbing with nylon-bristle brushes spraying and washing with clean water. However, mould and algae aggregations that were stubborn or were on delicate decoration, or on sediment banks and porous bedrock were sprayed with a sodium hypochlorite solution (Figure 7). Cleaning the Bath of Venus was a challenge. There were algal blooms on delicate crystals beneath the pool surface and the water was noticeably discoloured (Figure 8). The initial cleaning attempts were not very successful. After discussions with senior NPWS staff, it was agreed the Bath of Venus should be completely drained to enable the blooms to be dealt with more effectively.

Figure 6: Much of the cave was swept, scrubbed and washed with local water and dirt and runoff from the washing was removed with a vacuum cleaner

Figure 7: Preparing to spray a stubborn patch of mould with sodium hypochlorite solution

All contaminated water and water draining from the areas being cleaned, was immediately captured with wet-dry vacuum cleaners and removed from the cave. This included all water drained from the Bath of Venus.

Figure 8: Cleaning the Bath of Venus was a challenge. There were algal blooms on delicate crystals beneath the pool surface and the water was noticeably discoloured.

While the cleaning work was in progress, guided tours were re-directed to Jersey Cave and a decision was subsequently made to continue with those tours so that Jillabenan Cave could be 'rested' for a couple of weeks. When Jillabenan did reopen, it was for no more than two tours a day.

Towards the end of 2021, arrangements were made for a former staff member to prepare cave monitoring guidelines and a cleaning and maintenance schedule for the caves. The extent to which these have been fully implemented is not known to the author.

Follow-up inspection visits of Jillabenan by members of the cleaning team took place in June, July and November, 2021, in November 2022, and again in February 2023. The 2021 visits indicated the cave had recovered well. While areas of stained flowstone (from rat droppings) remained, there was a scattering of fresh rat pellets (the hole in the door had not been dealt with). There were a few small areas of black mould but no sign of any brown growths. By November 2021, the Bath of Venus was full, and staff had noticed the Bath of Venus Springtails had returned (Figure 9). On the November 2002 visit, the cave was again considered to be in generally good condition. However, there was a small area of lampenflora midway into the cave and there were rat droppings with a variety of fungi growing on them observed on flowstone and cave corals. The 2022 observations suggest that issues with illumination, rats and monitoring and cleaning were still to be fully resolved.

Figure 9: The Bath of Venus in November 2021. It was full, there was no sign of algal blooms and its resident Springtails had returned. The darker patches in the water are shadows of calcite rafts floating on the pool surface.

Summary and conclusions

2023 marks the 110th anniversary of Jillabenan Cave first being opened for public inspections. Over the years, the cave has been substantially modified to enable safe, comfortable and convenient access for visitors. The first phase of development commenced with excavation of the walk-in entrance and cave

pathways, and concluded with the installation of electric lights in 1926. The cave infrastructure was upgraded in the late 1960s and again in 1989-90 when pathways were modified to enable wheelchair access and a new lighting system was installed. The new system included many bright floodlights to highlight cave features. Lampenflora risks were managed by carefully aiming the lights, limiting the number of daily tours and, from 1992, by systematically recording lampenflora locations and promptly treating any outbreaks.

There are gaps in the records of visitor numbers to Jillabenan. However, they do show that over a 30-year period to the end of the first decade of the 21st Century, visitor numbers averaged around 3400 a year. Precise details on the number of tours each day are hard to locate, but it seems it was common for up to four trips a day to be conducted during summer and no more than two a day at other times of the year.

Records suggest the cave used to be cleaned annually and that in 1992, a register of cleaning issues and activities was commenced. In the mid-2010s, it appears regular cleaning of the cave was discontinued. Some *ad hoc* lampenflora control work continued, but the cessation of regular cleaning resulted in the gradual accumulation of any lint and dirt unintentionally shed in the cave by visitors, as well as the droppings left behind by visiting rats.

Early in 2020, a major bushfire burnt over the Yarrangobilly karst and left a layer of ash on the surface. Around that time, the global Covid-19 pandemic spread to Australia and in response, governments introduced restrictions that in NSW included the closure of all caves managed by the state government. The whole of the Yarrangobilly area was closed to the public for many months as a result of bushfire impacts and Covid restrictions. As travel restrictions eased and with the development of Covid-safe measures, it became feasible to reopen some parts of the Yarrangobilly area. Jillabenan Cave was the first cave to be reopened. There was huge pent-up demand for tours and to cater for this, there were up to eight or nine tours a day. This was double the number of tours normally conducted over the busy summer months.

Rainfall over the 12 to 18 months following the bushfire was higher than average. As Jillabenan lies relatively close to the surface, it did not take long for water to seep into the cave, bringing in dissolved components from bushfire ash. Water also made speleothems active, or more active. It dampened other cave surfaces, topped up the Bath of Venus, formed puddles on and near pathways and filled microgours and other depressions in flowstones. It also moistened the blowfly carcases, rat droppings, lint and tracked-in dirt that had accumulated in the cave over the previous decade.

Staff did not appear to fully appreciate the implications of not regularly cleaning the cave and the resulting accumulation of organic matter and nutrients in the cave, or of the likely impacts of greatly increasing tours and visitor numbers. Wet conditions brought the cave to a tipping point.

Water not only carried nutrients from surface ash into the cave, but also made nutrients already in the cave more readily available to microbes. Water appears to have been the key factor that when combined with the other issues affecting the cave, resulted in the widespread microbial blooms in the cave during the first quarter of 2021.

During that period, water was not at all positive for Jillabenan Cave.

References

Anon. (2015). Kosciuszko Karst Area Management Plan, NSW National Parks and Wildlife Service, *Office of Environment and Heritage*, 48pp.

Aplin, Ken, Ford, Fred & Hiscock, Peter. (2010). Early Holocene human occupation and environment of the southeast Australian Alps: New evidence from the Yarrangobilly Plateau, New South Wales. In: *Altered Ecologies: Fire, climate and human influence on terrestrial landscapes, Terra Australis,* **32**, 187-212. Australian National University E-Press, Canberra.

Bilton, Gary. (2010). The Centenary of the Discovery of Dudley er … Jillabenan Cave 1910-2010. Journal of The Sydney Speleological Society, **54**(6), 151-173.

Hoad, Colin W. (2004). Yarrangobilly: People and Caves, self-published by author, Tumut, NSW. 138pp.

Pittman, E F. (1912). Report on Limestone Caves. *Annual Report of the Department of Mines NSW for 1911*, p194, citing reports furnished by O. Trickett.

Trickett, O. (1911). Report on Caves. *Annual Report of the Department of Mines NSW for 1910*, p194.

Trickett, O. (1913). Report on Limestone Caves. *Annual Report of the Department of Mines, NSW for 1912,* p193.

Trickett, O. (1914). Report on Limestone Caves. *Annual Report of the Department of Mines, NSW for 1913,* p185.

Trickett, O. (1917). Guide to Yarrangobilly Caves, New South Wales. Second Edition, *NSW Immigration and Tourist Bureau*, 46pp.