

Cave Climate Graphs on the ACKMA Website V3

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During 2020 ACKMA instigated the deployment of data loggers to a number of cave sites throughout Australia and New Zealand. This was an attempt to capture the best baseline climate data for all these caves, as visitation to the caves had been halted due to COVID-19 restrictions. The data collected currently starts from the 28/05/2020 and runs to 13/02/2023. Overall, the maximum number of data records is 126210 with Yonderup Cave at Yanchep WA providing the most continuous data set so far.

The ACKMA Cave Climate Graphs web page shown in *Figure 1* has changed dramatically since 2020 as data has continued to be provided from the ACKMA data loggers from many of our collaborating sites. The graphs have had to be separated down to a maximum of two years of data display because the internal & external temperature graphs could not be displayed once the number of data points past the 80,000 mark - so for each site the available data years is calculated each time the data is updated and only those years with available data for each site are displayed on the ACKMA Cave Climate Graphs web page.

The links page is shown below in *Figure 1* and is at <https://ackma.org/CaveClimate/index.asp>.

When the Temperature, Relative Humidity or Internal/External links are clicked on, then the relevant graph is prepared by loading the data from the website and generating the graph.

An additional change has been made in the graph displays relating to the date on the X axis which is now displayed weekly for single year graphs and monthly for two-year graphs. The time is now displayed in military time with a 24-hour clock.

Each 10-minute data point is tagged individually so as you move your cursor over the graph you can see the date and time of the point as well as the temperature or relative humidity value. Note also that the smallest temperature measurement recorded by the data loggers is 0.1 °C.

Examining the Yonderup Cave Highest Temperature Fluctuations

Using the zoom feature of the graphs the five highest temperature peaks were examined over the 2020-22 data sets for Yonderup Cave.

Table 1 shows the start times and temperatures of the peaks until the temperature returned to the starting temperature. The zoomed view of the first peak on the 11-Aug 2020 is shown below in *Figure 2*. It is labelled with the Start, Peak, Close and Return to Start Temp points used in all of the peaks examined for Yonderup Cave.

These five highest temperature peaks were thought to be related to cave visitations. However, when visitation data was compared to the dates of the five highest peaks only one correlated to a cave tour which consisted of only 3 people.

Rob Susac suggested that the peaks may relate to visits by rats, whose scats were being found in the cave and it became apparent that there had been an increase in rat activity. The logger is less than 0.5m off the floor of the cave and easily climbed by a rat.

Rob also indicated that visitors to the cave passed closely by the logger (less than 1m) as it is by the only path next to the display of gypsum crystals which is a feature of the tour. The tour group generally takes about 30 minutes to reach the data logger location from the tour start time. The tour guide generally stops near the data logger (approximately 0.5m away) while talking to the tour group. Visitors may also linger around the data logger while viewing the nearby gypsum or other features. The tour group also returns past the data logger location about 10 minutes later as they depart the cave. The tour guide does not typically pause at the data logger on the way out.

[Click here for a map showing these cave locations](#)

Figure 1: Cave Climate linkage page from the ACKMA website <https://ackma.org/CaveClimate/index.asp>

Year	Date	Data	Start	Peak	Close	Return to Start Temp	Total Time
2020	11-Aug-20	Time	15:29	15:49	16:29	17:29	2:00
		Temp °C	17	18.2	17.1	17	
		Temp Diff °C		1.2	-1.1	-0.1	
2020	25-Aug-20	Time	10:59	11:19	11:59	12:19	1:20
		Temp	16.8	17.5	16.9	16.8	
		Temp Diff °C		0.7	-0.6	-0.1	
2021	5-Jun-21	Time	14:47	14:57	15:27	15:47	1:00
		Temp	17.2	17.9	17.3	17.2	
		Temp Diff °C		0.7	-0.6	-0.1	
2021	31-Jul-21	Time	13:57	14:07	14:37	15:07	1:10
		Temp °C	17.1	17.8	17.2	17.1	
		Temp Diff °C		0.7	-0.6	-0.1	
2022	25-Nov-22	Time	9:57	10:07	10:27	11:07	1:10
		Temp °C	17	17.5	17.1	17	
		Temp Diff °C		0.5	-0.4	-0.1	

Table 1: Yonderup Cave five top temperature fluctuations 2020-22



Figure 2

Examining the Yonderup Cave Temperature Fluctuations on Tour Dates

The dates and times of tours undertaken in January 2023, which started on the 19th January, were examined on the dates that tours occurred until the 30th January 2023.

Yonderup Cave Tours January 2023																
Date	Tour Time	No of Visitors	Temperature Variation °C	Return Time mins	Tour Time	No of Visitors	Temperature Variation °C	Return Time mins	Tour Time	No of Visitors	Temperature Variation °C	Return Time mins	Tour Time	No of Visitors	Temperature Variation °C	Return Time mins
19/01/2023					10:30	3	0.1	40	13:00	8	0.2	100				
20/01/2023					10:30	4	0.1	50	13:00	5	0.2	Did not	14:30	6	0.1	120
21/01/2023					10:30	6	0		13:00	11	0.1	30	14:30	4	0.1	20
22/01/2023					10:30	8	0		13:00	9	0.2	30	14:30	11	0.2	60
23/01/2023					10:30	5	0.1	40	13:00	11	0.1	50	14:30	4	0.1	50
24/01/2023									13:00	6	0.1	50	14:30	4	0.1	40
25/01/2023	9:30	4	0.1	60									14:30	4	0.1	50
26/01/2023	9:30	3	0.1	20	11:00	9	0.1	70	13:00	9	0.2	Did not	14:30	10	0.1	30
27/01/2023					11:00	9	0.1	80	13:00	11	0.1	20				
28/01/2023					11:00	9	0.1	50	13:00	10	0.2	80	14:30	7	0.1	90
29/01/2023									13:00	9	0.2	40	14:30	6	0.2	50
30/01/2023					11:00	7	0.1	50	13:00	5	0.1	20	14:30	4	0.2	40

Table 2: Yonderup Cave Tours January 2023

Cave tours did occur on the 31st January 2023 but the data from the data logger has not yet been submitted.

As January is generally a hot month it is expected that the overall air temperature of the cave should rise over this period.

Yonderup Cave Tours 19/01/2023

Two tours were conducted on the 19/01/2023 at 10:30 (3 visitors) and 13:00 (8 visitors). The temperature data for Yonderup Cave on the 19/01/2023 is shown in *Figure 3*. The rise of 0.1°C from the current daily base temperature of 17.5°C , starts at 10:56, approximately 30 minutes after the tour starts, and returns to the base temperature at 11:36. The return time is shown in Table 1 as 40 minutes.

Then there are four 0.1°C fluctuations before the 0.2°C rise at 13:26 caused by the 13:00 tour. The return time on the 13:00 tour is 100 minutes which is probably due to the larger group size resulting in a longer time before the daily base temperature is reached. It may also be longer as the base temperature is on the rise as well.

Note also the flat line 17.5°C during the night and then the start of the 0.1°C fluctuations during the day. These fluctuations appear to be the precursor to the overall base temperature rise to 17.6°C which occurs on the 20/01/2023.



Figure 3.

Yonderup Cave Tours 20/01/2023

Three tours were conducted on the 20/01/2023 at 10:30 (4 visitors), 13:00 (5 visitors) and at 14:30 (6 visitors). The temperature data for Yonderup Cave on the 20/01/2023 is shown in *Figure 4*. The rise of 0.1°C from the current daily base temperature of 17.5°C , starts at 10:56, approximately 30 minutes after the tour starts, and returns to the base temperature at 11:46. The return time is shown in Table 1 as 50 minutes.

The base temperature rise of 0.1°C to 17.6°C occurs somewhere after the 10:30 tour but cannot be specifically determined. The 13:00 tour results in a 0.2°C to 17.7°C but it returns to 17.6° after 20 minutes and stays there until the 14:30 tour causes another rise of 0.1°C to 17.7°C . The 14:30 tour rise is completed in twenty minutes and then the temperature is maintained and the new base level of 17.6°C throughout the night with only two fluctuations back to 17.5°C .

The day of the 21/01/2023 maintains the new base line temperature of 17.6°C . The full effects of the tours on the 20/01/2023 cannot be fully specified as the base temperature rose to 17.6°C during the tour times.

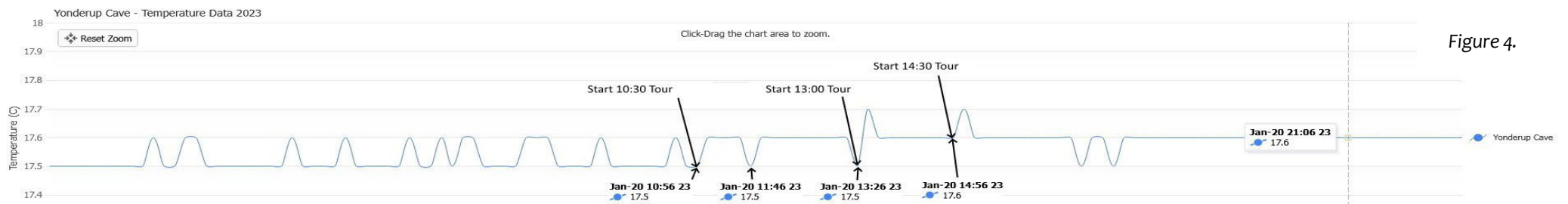


Figure 4.

Yonderup Cave Tours 21/01/2023

Three tours were conducted on the 21/01/2023 at 10:30 (6 visitors), 13:00 (11 visitors) and at 14:30 (4 visitors). The temperature data for Yonderup Cave on the 21/01/2023 is shown in *Figure 5*. There are five fluctuations to 17.5°C up until 7:36, but NO rise was registered by the 10:30 tour of 6 people. There are no obvious reasons why the 10:30 tour did not affect the cave temperature. This also occurs on tomorrow's 10:30 tour but then registers for all other days.

The 13:00 tour did register a 0.1°C rise in temperature that took 30 minutes to return to 17.6°C. Then the 14:30 tour registered a 0.1°C rise in temperature that took 20 minutes to return to 17.6°C. The differences in time to return to the 17.6°C temperature, is probably the group size.

Overall no other fluctuations in temperature occurred throughout the day and night.

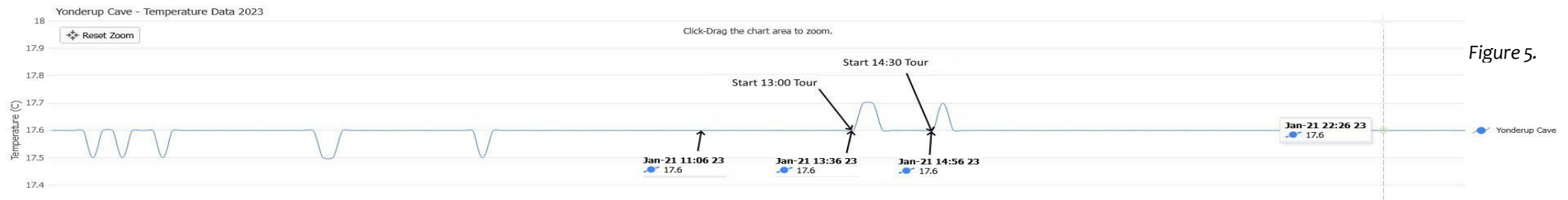


Figure 5.

Yonderup Cave Tours 22/01/2023

Three tours were conducted on the 22/01/2023 at 10:30 (8 visitors), 13:00 (9 visitors) and at 14:30 (11 visitors). The temperature data for Yonderup Cave on the 22/01/2023 is shown in *Figure 6*. There is only one fluctuation to 17.5°C at 1:46, but NO rise was registered by the 10:30 tour of 8 people. There are no obvious reasons why the 10:30 tour did not affect the cave air temperature.

The 13:00 tour did register a 0.2°C rise in temperature that took 30 minutes to return to 17.6°C. Then the 14:30 tour also registered a 0.2°C rise in temperature that took 60 minutes to return to 17.6°C. The differences in time to return to the 17.6°C temperature, is probably the group size as well as probably spending a longer time at the data logger position.



Figure 6.

Yonderup Cave Tours 23/01/2023

Three tours were conducted on the 23/01/2023 at 10:30 (5 visitors), 13:00 (11 visitors) and at 14:30 (4 visitors). The temperature data for Yonderup Cave on the 23/01/2023 is shown in *Figure 7*. The 0.1°C rise in temperature at 9:06 for 60 minutes does look like a group of visitors but no such group was recorded by DBCA.

The 10:30 tour did register a 0.1°C rise in temperature that took 40 minutes to return to 17.6°C. The 13:00 tour did register a 0.1°C rise in temperature that took 50 minutes to return to 17.6°C. Then the 14:30 tour also registered a 0.1°C rise in temperature that took 50 minutes to return to 17.6°C. The reason that the 13:00 tour and the 14:30 tour both took 50 minutes to return to the 17.6°C temperature is unknown. The fluctuation between the two tours may be a clue to why this occurred but it is unclear.



Figure 7.

Yonderup Cave Tours 24/01/2023

Only two tours were conducted on the 24/01/2023 at 13:00 (6 visitors) and at 14:30 (4 visitors). The temperature data for Yonderup Cave on the 24/01/2023 is shown in *Figure 8*. There are only two fluctuations and they are upwards to 17.7°C at 16:06 and 18:06. This would suggest that the base temperature's next direction is upwards.

The 13:00 tour did register a 0.1°C rise in temperature that took 60 minutes to return to 17.6°C. Then the 14:30 tour also registered a 0.1°C rise in temperature that took 40 minutes to return to 17.6°C. The return times do reflect the number of people in the groups and the length of time may be longer because the base temperature is trying to rise as well.

Note also that the time between the start of the 14:30 tour and when the data logger temperature change has reduced by 10 minutes as well.



Figure 8.

Yonderup Cave Tours 25/01/2023

Only two tours were conducted on the 25/01/2023 at 9:30 (4 visitors) and at 14:30 (4 visitors). The temperature data for Yonderup Cave on the 25/01/2023 is shown in Figure 9. There are only two fluctuations and they are both upwards to 17.7°C at 13:16 and 13:56. This would suggest that the base temperature's next direction is upwards.

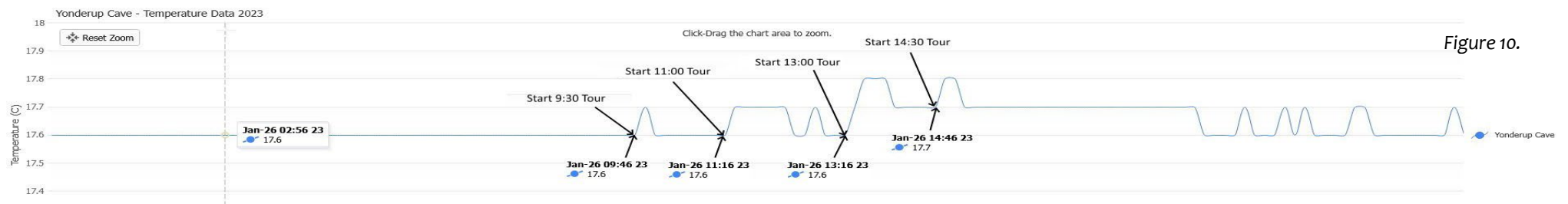
The 9:30 tour did register a 0.1°C rise in temperature that took 60 minutes to return to 17.6°C. Then the 14:30 tour also registered a 0.1°C rise in temperature that took 50 minutes to return to 17.6°C. The times for the temperature to return to 17.6°C do vary by 10 minutes, however the sampling time is also ten minutes, so depending when the group arrives and leaves the data logging station will also affect the time for the temperature to return to 17.6°C.



Yonderup Cave Tours 26/01/2023

Four tours were conducted on the 26/01/2023 at 9:30 (3 visitors), 11:00 (9 visitors), 13:00 (9 visitors), and at 14:30 (10 visitors). The temperature data for Yonderup Cave on the 26/01/2023 is shown in Figure 10. There are seven fluctuations and they are all upwards to 17.7°C. This would strongly suggest that the base temperature's next direction is upwards.

The 9:30 tour did register a 0.1°C rise in temperature that took 20 minutes to return to 17.6°C. The 11:00 tour also registered a 0.1°C rise in temperature that took 70 minutes to return to 17.6°C. The 13:00 tour registered a 0.2°C rise in temperature that never returned to 17.6°C. This appears to have occurred because 13:00 tour was still at 17.7°C when the 14:30 tour arrived and created another 0.1°C rise in temperature which only took 30 minutes to 17.7°C but took another 240 minutes (4 hours) to return to 17.6°C. This has occurred because the base temperature is trying to rise to 17.7°C but is still fluctuating between 17.6°C and 17.7°C until the next day when the base temperature does rise to 17.7°C.



Yonderup Cave Tours 27/01/2023

Two tours were conducted on the 27/01/2023 at 11:00 (9 visitors) and 13:00 (9 visitors). The temperature data for Yonderup Cave on the 27/01/2023 is shown in *Figure 11*. There are fourteen fluctuations before the 11:00 tour and they are all upwards to 17.7°C. After the 13:00 tour occurs the temperature does not return to 17.6°C but remains at 17.7°C, the new base temperature, and nine fluctuations occur back to 17.6°C but the base temperature remains at 17.7°C and then drops back to 17.6°C during the night/next morning. See the 28/01/2023 Tour data for details.

The 11:00 tour did register a 0.1°C rise in temperature that took 80 minutes to return to 17.6°C. The 13:00 tour also registered a 0.1°C rise in temperature that took 20 minutes to return to 17.7°C and stayed there until a possible 14:30 tour arrived with another 0.1°C rise in temperature that took 20 minutes to return to 17.7°C. The temperature then remained on 17.7°C with fluctuations back to 17.6°C during the night.

The visitor peaks and returns to starting temperatures are clearly affected by the rising base temperature during this day. Somewhere between 13:36 and about 17:00 the base temperature rose to 17.7°C and stayed there.



Figure 11.

Yonderup Cave Tours 28/01/2023

Three tours were conducted on the 28/01/2023 at 11:00 (9 visitors), 13:00 (10 visitors), and 14:30 (7 visitors). The temperature data for Yonderup Cave on the 28/01/2023 is shown in *Figure 12*. A base temperature change appears to have occurred between 11:26 on 27/01/2023 and 00:56 on 28/01/2023. The fluctuations change from dropping down from 17.7°C to 17.6°C to rising from 17.6°C to 17.7°C. After this point the base temperature becomes 17.6°C again.

The 11:00 tour did register a 0.1°C rise in temperature that took 50 minutes to return to 17.6°C. The 13:00 tour registered a 0.2°C rise in temperature that took 80 minutes to return to 17.6°C. The 14:30 tour registered another 0.2°C rise in temperature but the time appears to be too short for the group to reach the data logger (only 6 minutes after the tour started). So it is more likely there was a natural fluctuation of 0.1°C and then the tour arrived at the data logger causing another 0.1°C rise. If so then the temperature change took 90 minutes to return to the base temperature of 17.6°C.



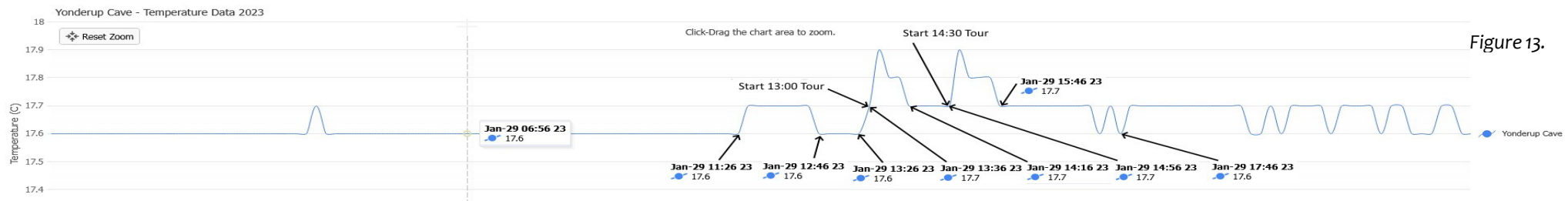
Figure 12.

Yonderup Cave Tours 29/01/2023

Two tours were recorded on the 29/01/2023 at 13:00 (9 visitors), and 14:30 (6 visitors). The temperature data for Yonderup Cave on the 29/01/2023 is shown in *Figure 13*.

The temperature rise from 11:26 to 00:46 looks like it could be a visitor group but there was no 11:00 tour group. Examining the 0.1°C rise at 17:46 (see *Figure 13*) and lasting for 2 hours and 10 minutes, the morning temperature rise from 11:26 to 00:46 looks very similar. The temperature appears to be trying to rise to 17.7°C.

The 11:00 tour rise is likely to be only 0.2°C from the 13:36 data point with the first 0.1°C rise resulting from the overall base temperature rising. The temperature then returns to the 17.7°C level after 40 minutes. Then the 14:30 tour has another 0.2°C rise which takes 50 minutes to return to the 17.7°C level. There are many 0.1°C fluctuations from 17.7°C to 17.6°C through the night and next morning but the 17.7°C level is maintained into the following day and lasts until the data ends.



Yonderup Cave Tours 30/01/2023

Three tours were conducted on the 30/01/2023 at 11:00 (7 visitors), 13:00 (5 visitors), and 14:30 (4 visitors). The temperature data for Yonderup Cave on the 30/01/2023 is shown in *Figure 14*. The many 0.1°C fluctuations from 17.7°C to 17.6°C are shown from the night of the 29/01/2023 into the morning of the 30/01/2023 to show how the temperature stabilised at 17.7°C just before the tours started.

The 11:00 tour temperature rise was 0.1°C which returned to the 17.7°C level after 50 minutes. The 13:00 tour temperature rise was 0.1°C which returned to the 17.7°C level after 20 minutes. The 14:30 tour had a 0.2°C rise which takes 40 minutes to return to the 17.7°C level. No further fluctuations occur until the data ends at 19:06.

This is one of the clearest examples of tours showing temperature rises from visitor groups but it does not correlate directly with the visitor numbers. If it did then the numbers should be 11:00 (7 visitors), 13:00 (4 visitors), and 14:30 (5 visitors) to produce the results shown in *Figure 14*. Clearly other factors such as time spent in proximity to the data logger and also how close the visitors were to the data logger must be factored into the correlation of results.



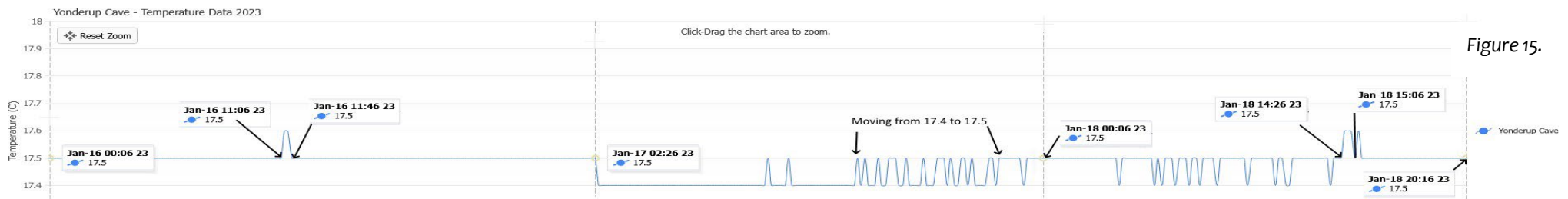
Overall View of Yonderup Cave Temperature Fluctuations on Tour Dates

Overall correlation of temperature rises with tour dates and times was very high with only two tours showing no temperature rises at all (see Yellow Cells in Table 2). There does not appear to be any reason for why these two parties, both 10:30 tours taken one day after the other (21 and 22/01/2023), did not generate any temperature rise. They were parties of 6 and 8 visitors so they would be very likely to register a temperature rise.

Attempts to correlate the size of visiting groups with the time taken for the temperature rises caused by the visitor groups to return to where they started from, prior to the group visit, were not successful. Sometimes smaller groups had longer times for the temperature to return to the starting temperature. Too many factors are in play, such as the length of time spent adjacent to the data logger, proximity to the data logger by the visitors and the rising or falling of temperatures due to overall heating or cooling of the cave system.

The base cave temperature started out at 17.5°C on the 19/01/2023 and rose to 17.6°C on the 20/01/2023. It maintained the 17.6°C base temperature until the 27/01/2023 when it rose to 17.7°C but then overnight reverted to 17.6°C. On the 29/01/2023 it rose to 17.7°C around 13:30 and stayed at that temperature until the end of the data set on the 30/01/2023.

We have also examined the three-day period prior to tours commencing from the 16/01/2023 to 18/01/2023 as a control to show that random events were not occurring at tour times. The data for those three days is shown in Figure 15. Note the remainder of 18/01/2023 data was a flat line at 17.5°C.



The majority of fluctuations in these three days was the temperature dropping from 17.5°C to 17.4°C then fluctuating until it returned to 17.5°C just before the start of 18/01/2023. There were also two obvious events over the three days, one on 16/01/2023 at 11:06 with a 0.1°C rise which took 40 minutes to return to 17.5°C. With no tours on this day this event is a random warming of 0.1°C with no known cause. A second event occurred on 18/01/2023 starting at 14:26 and taking 40 minutes to return to 17.5°C. This event was also a random warming of 0.1°C with no known cause.

All of the morning tours 9:30 or 11:00 have a 0.1°C rise whereas the afternoon tours are more likely to have a 0.2°C rise. This does not appear to depend upon tour group sizes. If the base temperature is changing with a 0.1°C rise then the 0.2°C afternoon rise may only be a 0.1°C rise. These generalisations are only likely to apply to the summer months.