# Six Seasons of Slow Worms at Cardiff University

2016 - 2021

Lee Raye

Cardiff University

**Six seasons of slow worms at Cardiff University**

Lee Raye

**2021**

Cardiff University

Cardiff



# Acknowledgements

This project would not have been possible without the interest and support from many nature-loving colleagues, including two (!) of Cardiff University's previous Chief Operating Officers.

Colleagues from Residences, especially the site management teams, have always been so kind and supportive of the project. The project was, of course, first authorised by the former Facilities Manager in Campus Facilities, who has always been a champion of environmental projects.

The Cardiff University Ecosystem Resilience and Biodiversity Action Plan steering committee (past and present) brings together some of Cardiff's most passionate and hardworking community members. It has been a pleasure working with them to create a plan to support slow worms (among other species and habitats) at Cardiff University.

My brilliant partner assisted with surveys, analysis and the editing of this report.

I have been lucky enough to have had conversations about the project with colleagues from as far away as the Federal University of São Carlos, Brazil (!) but especially contacts at ARC, ARG UK, FSC, and speakers and participants at the joint BHS-ARC meetings.

The Cardiff Wildlife and Cardiff Wildflower staff group on Yammer has been an unfailing source of motivation and inspiration to me and I am grateful for all the generous comments and suggestions that the project has received over the years.

Finally, and most importantly, the Cardiff University Grounds Maintenance Team based in Sport created the slow worm area and maintained it for five years. Their strength, skill, knowledge and sense of humour are examples to the rest of the university.

Thank you all.

# Contents



# Summary

**What:** The slow worm is a harmless species of lizard that is native to Britain. This document reports on a project which aimed to preserve and monitor the slow worms at Cardiff University. It also tracks a slow worm population crash which started in 2020. The slow worms are recovering from this crash now. It is estimated that there are currently nine slow worms present on site. Photographs of most of them are included in this report with identification notes.

**When:** This project was planned in 2015 and has now run for six field seasons (2016-2021). Slow worms were monitored weekly or fortnightly during the field season. The first formal population survey was run in 2021.

**Who:** Following a proposal by the author of this report, the project was first authorised by the previous Facilities Manager in Campus Facilities in 2015. The creation of the slow worm area on site and its initial expert maintenance was carried out by the Grounds Maintenance team from Cardiff University Sports Fields, Llanrumney. The maintenance has since been passed on along with the Grounds Maintenance Contract (in 2020-21 it was carried out by Crown Gardens). All surveys have been carried out by the author of this report in a voluntary capacity, and each survey is conducted with permission from site management. In the future responsibility for this project is likely to be taken on by the Ecosystem Resilience and Biodiversity Action Plan Steering Committee.

**Where:** The site of the project is a student residence set away from main campus and adjacent to a railway track. The exact location of the site is kept secret in order to protect the slow worms from intentional and unintentional harm and capture. Key contacts in Estates, Residences, and on the Cardiff University Ecosystem Resilience and Biodiversity Action Plan Steering Committee are aware of the location. All records (incl. location information) have been submitted to the Record Pool (www.recordpool.org.uk), the UK's recording portal for herpetological records run by Amphibian and Reptile Conservation and the Amphibian and Reptile Groups of the UK. Cardiff University Sports Fields retain a laminated slow worm skin from the site as part of a poster display (it was sadly refused by Cardiff University's Institutional Archives!).

# Background

## Slow worms

The slow worm (*Anguis fragilis*) is a species of legless lizard. Through a process of convergent evolution, slow worms have lost their limbs and grown to look like snakes, but they are completely harmless to humans. They don't bite and are not venomous. They range in colour from copper brown and creamy pink to silver and dark grey. The shade of colour is not a reliable guide to identification because it can vary as slow worms slough their skins (Platenberg 1999). On other sites in Cardiff males are occasionally found with blue spots, but this pattern has not yet been recorded at our site at Cardiff University. They are often valued in gardens because they eat slugs, worms, spiders and insects. When disturbed they are capable of dropping their tails (which continue to wiggle for some time to distract predators) but unlike in other lizard species slow worms seem to only be able to use this defence once in their lifetime (Beebee and Griffiths 2000 p. 116). Slow worms show very high site fidelity, and although their home range size seems to vary, slow worms typically do not move very far: Smith (1990) who covered a site in refugia found they typically did not move more than 4m per day.

Slow worms are often said to be cryptic (camouflaged) and semi-fossorial (burrowing): They spend much of their time underground, or under leaves and beneath the thatch of grass. Their long, smooth, limbless bodies appear to be adapted to allow them to fit into very tight spaces. Slow worms are ectothermic and they thermoregulate to keep their body near an optimum temperature. Slow worms do practice mosaic-basking (warming themselves in the sun whilst half concealed by foliage), but much more commonly they seek out areas where the warmth of the sun is absorbed so they can warm themselves whilst remaining hidden under something (this is 'thigmothermic' behaviour). At Cardiff University slow worms have even been recorded apparently lying on their backs and turning upside down to bask (see photograph opposite and compare Hails & Strine (2016)). Slow worms hibernate in the winter underground or in warm places like compost heaps.

The slow worm is one of the species that is native to Britain but not to Ireland. In Wales it is best recorded in the lowland coastal regions and along the English border (Beebee and Griffiths 2000 p. 123): Slow worms are especially well recorded around Cardiff, but rarely recorded in, for example, the Brecon Beacons, although this may be at least partially due to unequal survey effort in the two areas. It is hard to be clear about the general trend of the slow worm, but the species seems to be in decline in south east England at least (Beebee and Ratcliffe 2018) and it probably declined more generally during the 20$^{th}$ century (Prestt et al. 1974).

In Welsh the slow worm is often called the *slorwm* or the *neidr ddall* (blind snake) perhaps because it has smaller eyes, and has eyelids, unlike true snakes. It is also called *neidr ddefaid* (sheep snake), perhaps because it was often found in sheep sheds (Jones 2009).

At time of writing, slow worms are protected from harm and from sale by Schedule five of the UK *Wildlife and Countryside Act* (1984), although the government has indicated it has plans to remove their protection in 2021 (JNCC 2021). At Cardiff University, slow worms have also been nominated as one of the priority species on the *Ecosystem Resilience and Biodiversity Action Plan* (Bruford et al. 2020).

## The site

Slow worms are only known to be present at one site at Cardiff University. This is a residential site alongside a railway track away from the main academic campus but within the Cardiff ring road. Slow worms were first recorded here in 2015 (there are no older records for the postcode), and part of the site has been managed to support slow worms ever since.

The site includes a mosaic of shrubs and 225m$^2$ of steep rough grassland. The rough grassland is mowed once a year (in November, after the slow worms have gone into hibernation). Three *refugia* (squares of corrugated roofing material or tin) have been placed on the site. The refugia absorb warmth from the sun, and slow worms can warm up more quickly by basking underneath them. These consist of:

- **Tin refugia / Refugia #1** : this is a sheet of olive-green corrugated tin, 100cm x 130 cm. It is set on grass.
- **Roofing refugia / Refugia #2** : this is a sheet of black corrugated roofing material, 100cm x 70cm. Set on grass.
- **Roofing refugia / Refugia #3** : material and size as Refugia 2. Set on ivy.

In addition to these, a *hibernaculum* compost area has been set up, which is topped up at the beginning of autumn each year with a mixture of fallen leaves and grass clippings in the hopes that slow worms could use it to hibernate.

**The exact location of the Cardiff University site is kept secret to protect the slow worms.** There is an old (and totally false) piece of folklore that slow worm "stings" can be deadly to humans, and people sometimes mistake them for venomous snakes and exterminate them. Even when people know that slow worms are not harmful, they are occasionally targeted: In the recent past, at least one individual at Cardiff University has admitted capturing slow worms in order to introduce them into a garden environment to control slugs (pers. comm. 2021).

**A slow worm's poem**

*If I had one eye,*
*As thou hast two*
*No man should live,*
*Nor beast should loo (low)*
*(Owen 1887 p. 365)*

## History of the project

### *Before the project started*

In 2015, part of the site was left unmowed due to a broken machine. When the grass was finally mowed, a member of the grounds maintenance team at Cardiff University Sports Fields found a slow worm on site. Based on this, I submitted a proposal for the site to adopt a slow worm friendly management plan (reducing grass and hedge management to a single cut each year, in November).

### *The first season (2016): A new management plan*

In 2016, the new management plan was accepted which allowed the area of the site where the slow worm had been seen to be left unmowed by the Cardiff University grounds maintenance team. I placed a corrugated tin refugium in the slow worm area to allow surveying. I visited once a fortnight through the first season.

In the first year I recorded a peak count of six individual slow worms found on one visit. Juvenile slow worms were present in the first year of surveying.

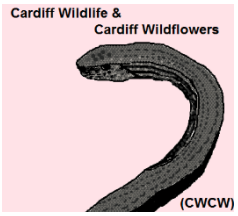
### *The second season (2017): Attempted conversion to summer meadow*

In 2017**,** As part of a larger project to establish seven wildflower areas around Cardiff University, the Cardiff University Grounds Maintenance team seeded the slow worm area with a native, perennial clay-soil wildflower mix in spring 2017. We seeded the slow worm area in furrows, in the hopes that we could avoid disturbing the slow worms. Unfortunately, the seed did not take very well (presumably it was overshadowed by the grass). We also seeded an adjoining area which had previously been treated with glyphosate. This responded much better and has acted a seed-reservoir. Seeds occasionally pass from this area into the longer grass of the slow worm area.

This season I also started sending out a monthly slow worm newsletter to raise awareness about the slow worms and allay any fears about their presence on site.

At the end of the second season, two additional refugia and a hibernaculum were placed on site, this helps explain the higher peak counts in 2018 and 2019 compared with 2017, although it is worth noting that even if we exclude Refugia #2 and #3 from the counts, the peak count continues to rise. In the second season the peak count rose to eight individuals found on a single site visit (all under Refugium #1).

### *The third season (2018): Surveying on a construction site*




In 2018, I set up the Cardiff Wildlife and Cardiff Wildflower (CWCW) staff network on Cardiff University's internal social network, Yammer. This replaced the monthly slow worm newsletter and allowed pictures of the slow worms to reach a wider audience. The current logo for the staff network is a slow worm.

Through most of this season the slow worm area was closed to public access as contractors were working on site. I was able to continue to access the site to survey once a week under the supervision of the construction site manager and wearing appropriate PPE. From this year onwards I began checking the slow worms every week through the summer period.

The slow worm peak count rose this year to twelve individuals found on a single site visit, although if we exclude Refugia #2 and #3 the peak count under Refugium #1 remained the same.

### *The fourth season (2019): Community interest*

In 2019, I launched a consultation in the Cardiff Wildlife and Cardiff Wildflower staff network about which species should be our priorities at Cardiff University. Slow worms were quickly chosen as

one of the priority species, and I drew up a plan to help protect these species and the habitats which they live in.

The rough appearance of the slow worm area continued to be unpopular, and in the autumn I seeded the slow worm grassland area with yellow rattle, in an attempt to slow grass growth and allow wildflowers to colonise the area.

The slow worm peak count remained at twelve this year, and ten individuals were seen under Refugia #1 alone.

### *The fifth season (2020): A population crash during Covid-19*

In 2020, the Cardiff Wildlife and Cardiff Wildflowers plan was inherited by the Ecosystem Resilience and Biodiversity Action Plan Steering Committee. Our Steering Committee adapted the plan into a full *Ecosystem Resilience and Biodiversity Action Plan*, which was approved by Cardiff University Council in November 2020.

2020 was a disastrous year for the slow worms. I only found slow worms on 7 of the site 21 visits in 2020, and the peak count on a single visit was two individuals. It seems probable that the population underwent a population crash, but because I was not able to access the site between the end of March and the end of June (due to Covid lockdown in Cardiff) some vital evidence from this period is missing. It is possible to speculate about two possible explanations:

Anecdotally, in September 2019 there was some building work off-site, on the other side of the railway. This involved the clearing of fly-tipped litter and soil from an area and a new residential construction. This may have removed a possible hibernation site for the slow worms, meaning that fewer survived the winter. The construction also seemed to attract (or perhaps displace) rats (*Rattus norvegicus*) onto Cardiff University land. I found rats under refugia during multiple surveys in September in 2019. Later, due to Covid, the residents left the site in the middle of March 2020, just as the slow worms were due to emerge from hibernation. I did not see any slow worms before lockdown began in March, but when I returned to site, I again found rats under the refugia in July and August 2020, If the rats were present all year, it seems possible that they might also have disturbed, or perhaps even preyed upon the slow worms in the area.

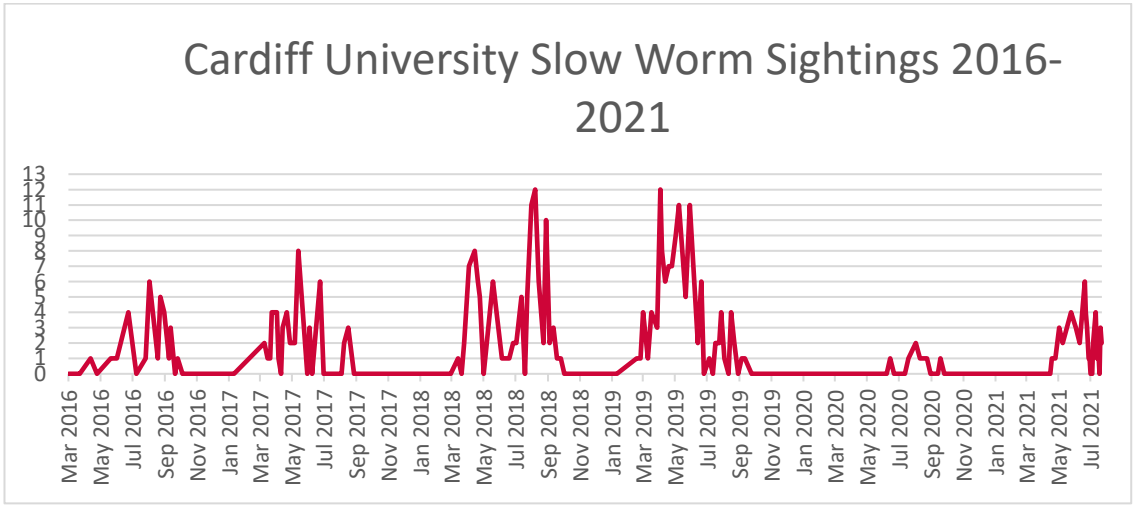
Alternatively, the spring of 2020 (although not the the winter and summer) was also exceptionally dry (National Drought Group 2020). Anne Riddell, monitoring the slow worms at Canterbury Environmental Education Centre in 1995 found that following a drought (where there was little rain between the 14th June and 2nd September and temperatures rose to 31.5°C), the local slow worm population seems to have been decimated. Some of the slow worms seemed to go into aestivation (summer hibernation), but of the 105 individuals identified in the population, only 14 were seen at the end of the season. This suggests that the reduction in slow worm population observed at Cardiff University in 2020 could simply have been due to the dry weather, which in

turn was probably influenced by climate change. This would be the more worrying explanation because Christidis et al. (2021) estimate that while before global warming, summers as hot as in 2020 would have only come once every ninety years, we can now expect them as frequently as once every other year.

***The sixth season (2021): The population survey***

In 2021, in an effort to understand the slow worm population better, I conducted a population survey (see next section). The survey suggested that only nine individual slow worms used the refugia on site in August 2021. It is hoped that future seasons will see slow worm populations rising.

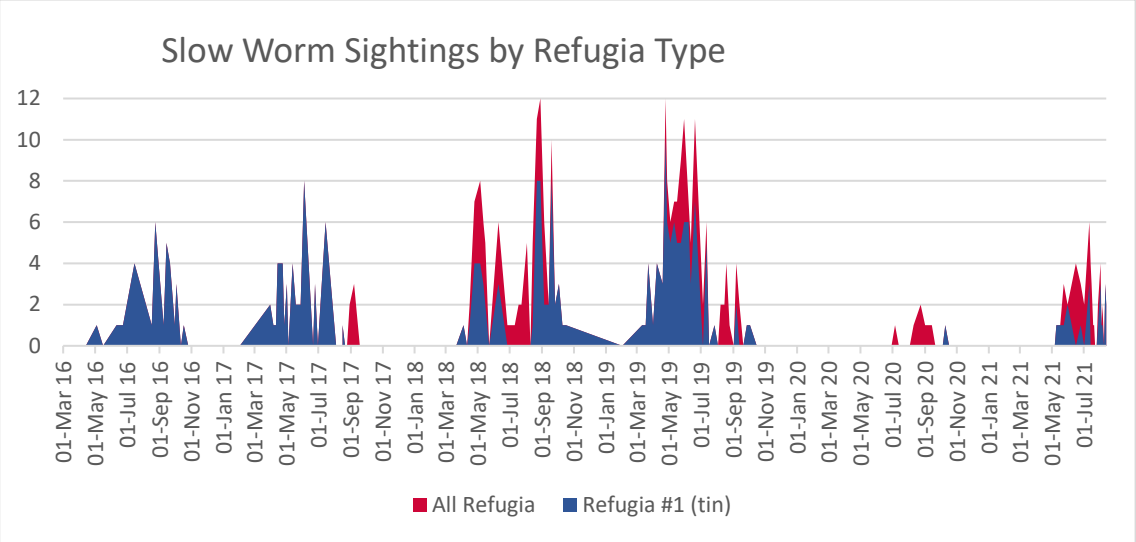
The peak count recovered this year back to six individuals found on a single visit – the same level as in the first season. This might indicate the population is recovering. No rats were found all year, but a new cat has been present on site during most of my surveys.



# Survey Results and Analysis

## Survey count trend

As described in the History of the Project section above, the trend of the slow worm survey count can be described as an apparent slow rise from 2016, to 2018, a steady year in 2019, and then a sudden crash in 2020. However, the rise in population is explained, at least partially, by the placement of two additional refugia at the end of the 2017 season. The following chart compares records for all refugia with those from just Refugia #1 to provide perhaps a fairer view of the situation.




The increased survey count between 2017 and 2019 is far more subdued when we look at just the blue records from the original Refugium. The increase might therefore have been due to sampling bias. Refugia #1 and #2 (the most important Refugia) are only about 5m apart, so it is debateable whether the placement of the new Refugia allowed the surveying of additional individuals. It is more likely that the additional refugia allowed individuals more choice and space to bask, increasing the likelihood of finding a higher proportion of the population on each trip.

Unlike the possible population rise in 2018 and 2019, the population crash in 2020 cannot be explained due to a sampling bias. The roots of the 2020 crash might possibly be found at the end of 2019 (fewer slow worms were seen on each visit in the second half of the season, from July to October). In 2021 the number seen on each survey rose slightly, back to a peak count of six slow worms on a single site visit. Assuming the number seen on each survey, and the peak count is closely related to the number of slow worms present on site, this is likely to reflect a population crash and the start of a recovery. The majority of slow worms on site in 2021 were small adults, presumably recruited from neighbouring areas.

## Population abundance surveys

**Note: Except when animals are being rescued (e.g. from cats), due to the risk of disease, injury and stress to people and animals, reptiles should only be handled by trained individuals with biosecurity safeguards in place.**

The relationship between the number of slow worms found on each survey and the number of slow worms present in an area differs from site to site (Smith 1990 p. 27). While there is a correlation, on sites which are not covered with refugia, a subpopulation of slow worms is likely to use natural refugia and practice mosaic-basking meaning that they are never seen by surveyors (Platenberg 1999). Despite this, there does seem to be a relationship between the two numbers. Natural England's (2011 pp. 22, 30) *Reptile Mitigation Guidelines* suggest that, given 30 refugia on a very small site a survey count of less than ten slow worms indicates a small population size, a survey count of 11-40 slow worms indicates a medium population size, and a survey count of over 41 slow worms indicates a large population size. There are only three refugia in place on the Cardiff University site, but even with these restrictions, Cardiff University's slow worm population would have qualified as at least medium size (peak count 12) in 2018 and 2019.

Between the 14th of July 2021 and the 13th of August 2021, the site was visited thirteen times. Most of these visits were in the early afternoon, which has historically been a good time to survey the site. This is because, in the morning the sun does not hit the rough grassland area where slow worms are found, and it typically grows hotter later in the day which makes surveying less reliable in July and August. However, the site was also surveyed once at 7:30am and once at 5pm to ensure that the slow worms at other times of day were the same individuals. On each visit, the slow worms present were caught, placed in a bucket, and then moved individually into a squash box (a repurposed transparent plastic box filled with sponges, to allow their undersides to be photographed).

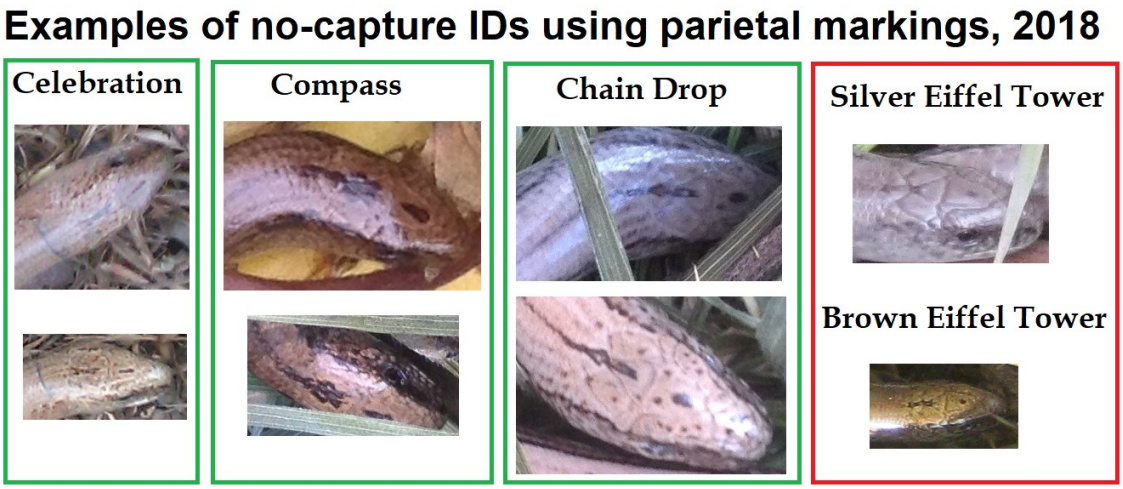
**Animal welfare and biosecurity measures taken for 2021 population survey:**

- Each individual was kept only long enough to allow it to be photographed (usually 5-10 minutes, but more when multiple animals were captured.)
- Bucket was covered after slow worms were captured so they did not feel vulnerable.
- Hands were washed before survey. Disposable (not reusable) nitrite gloves were worn at all times whilst handling slow worms. Hands were disinfected with alcoholic gel following the survey.
- Squash box and bucket were washed with hot water and bleach, rinsed and left to dry after each survey.
- No slow worms were marked.
- All slow worms were allowed to move away by themselves.
- Parking was on concrete, so car tires did not need to be disinfected.

Four of the thirteen visits (31%) were unsuccessful (no slow worms were present). On the remaining nine visits, a total of seventeen slow worms were captured. Slow worms have unique markings on their chins and heads, and during each visit, each slow worm was photographed. Each slow worm was also later digitally measured (both from snout to vent, and total body length). The measuring was based on comparing the size of the photographed slow worm to the size of the ruler tape on the outside of the squash box. This was not entirely accurate, and all sizes have been rounded to the nearest 10mm (they are still likely to be unreliable). Photography and measuring allowed each slow worm to be identified if it was subsequently re-captured.

Of the seventeen slow worms captured (C) over the course of the nine useful surveys, there were only seven unique individuals photographed (M), and ten re-captures (R). This data was analysed using the Schnabel method (as presented in Krebs 2014). This method was chosen because the small number of slow worms captured on each survey occasion would not allow an accurate result from the Peterson method. The Schnabel method allows us to estimate population based on multiple capture/recapture events. Based on this method, we can estimate there were nine slow worms present on our Cardiff University site in August 2021 (within Poisson distribution 95% confidence interval 5-16). This is comparable to the low estimate of 4-20 slow worms per hectare found by Schmidt et al. (2019), and Platenberg's (1999) estimate of 24 slow worms living in Quilter's Wood, Kent, but much lower than Beebee's (2000 p. 121) estimate of 600-2,100 per hectare.

It appears that the population is lower in 2021 than in previous years. In 2018 and 2019, the peak count on a single survey day was twelve slow worms. This is double the peak count in 2021, and more than the total population calculated by the Schnabel method for 2021. In previous field seasons, individuals were identified based on no-capture photographs of their parietal (back of head and neck) markings (after Riddell 1997). In 2019 this method provisionally identified seventeen individuals, but identifying slow worms based on parietal markings alone is much less certain than using chin markings, so this number may be unreliable.




Based on the assumptions that there is a relationship between the peak count and the abundance on a site, and that, given the same survey conditions on the same site, this relationship is stable over time, we might suggest that the ratio provided by the 2021 figures (Peak Count (6) : Abundance (9)) could be used to back-estimate abundance in previous years. One issue with this is that, as explained in the Population Trend section, two refugia were added to the site at the end of the 2017 season. This might have resulted in a higher peak count. For 2016 and 2017 therefore, a different calculation might be required. A second possible ratio is to compare abundance with the peak season count under Refugium #1, which has been in place since the beginning of the project. This provides a ratio of (Peak count under Refugium #1 (3): Abundance (9)). These two ratios provide us with two estimates to go with the peak count in calculating abundance.

In the following table I have put the peak count in the final column accompanied by the ≥ sign, to show that this is the minimum population present on the site, and an estimate based on both the

ratios above in brackets, accompanied with a c. sign to show that this estimate is based on assumptions that may not be accurate:

| Year | Number of surveys | Peak count | Refugium #1 peak count | Average survey count | Population estimate |
|---|---|---|---|---|---|
| 2016 | 23? | 6 | 6 | 2 | ≥6 (c.9-18) |
| 2017 | 27 | 8 | 8 | 2 | ≥8 (c.12-24) |
| 2018 | 29 | 12 | 8 | 3 | ≥12 (c.18-24?) |
| 2019 | 33 | 12 | 10 | 4 | ≥12 (c.18-30?) |
| 2020 | 23 | 2 | 1 | 0 | ≥2 (c.3?) |
| 2021 | 26 (ongoing) | 6 | 3 | 2 | 9 |

The Schnabel method is reliable where the population is closed, and where every individual within the population has the same chance of being caught. The first assumption was likely met – the survey was completed within a month, which is a short enough period to assume that the slow worms are unlikely to have died, and young are not born until slightly later in August. However, the second assumption may not be correct. Of the seven individual slow worms caught, one trap-happy slow worm was caught six times (see photo below), whilst two others were caught only once. The survey was also carried out from July-August, which is one of the worst summer periods for surveying. Platenberg (1999) also had difficulty in using the Schnabel method (and others) to calculate slow worm population for the same reasons as above. Future population surveys at Cardiff University could confirm or correct the population number and ascertain whether the ratio of peak count : abundance is in fact stable and reliable, and, therefore whether the estimates above are likely to be accurate. They could also confirm whether (as it appears) the slow worm population is artificially low in 2021 and will recover.

**Cardiff University Slow Worm Population Survey July-August 2021**


***Pale with herringbone marks***
*Recorded x1 from 14th July*
*Snout-vent length c.130mm*
*Total body length c.240mm*

***Pale with flicked fork***
*Recorded x2 from 2nd August*
*Snout-vent length c.120mm*
*Total body length c.140mm*

***Speckled***
*Recorded x2 from 2nd August*
*Snout-vent length c.120mm*
*Total body length c.230mm*

***Yellow spot and blue splodge***
*Recorded x6 from 14th July*
*Snout-vent length c.150mm*
*Total body length c.260mm*

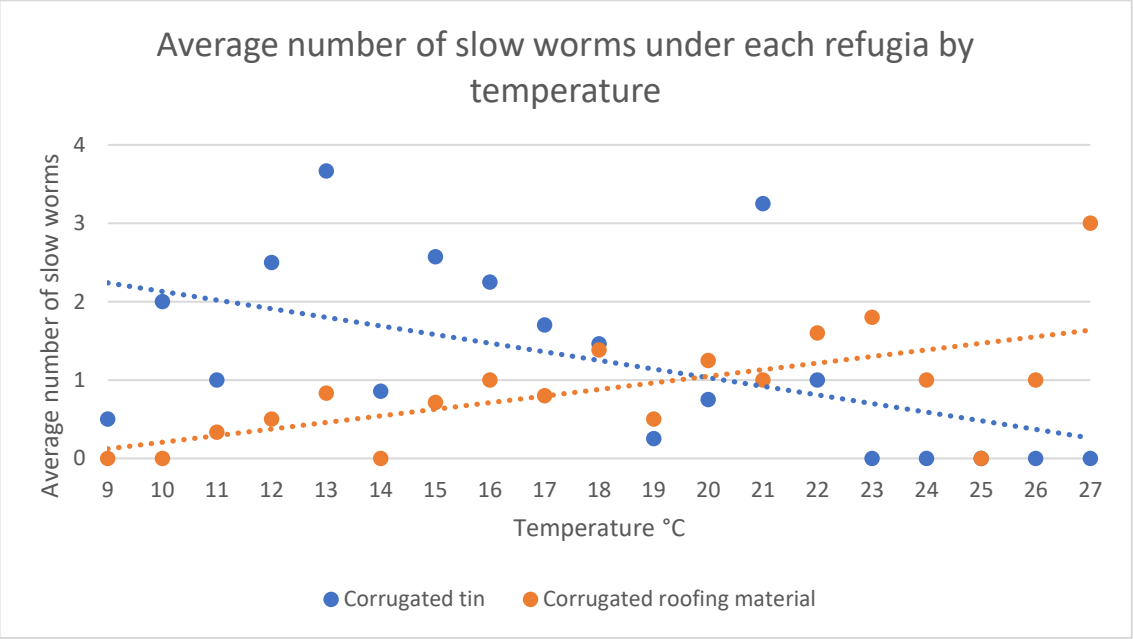
***Pale hearts***
*Recorded x1 from 21st July*
*Snout-vent length c.130mm*
*Total body length c.290mm*

***Pale spots***
*Recorded x3 from 16th July*
*Snout-vent length c.90mm,*
*Total body length c.190mm*

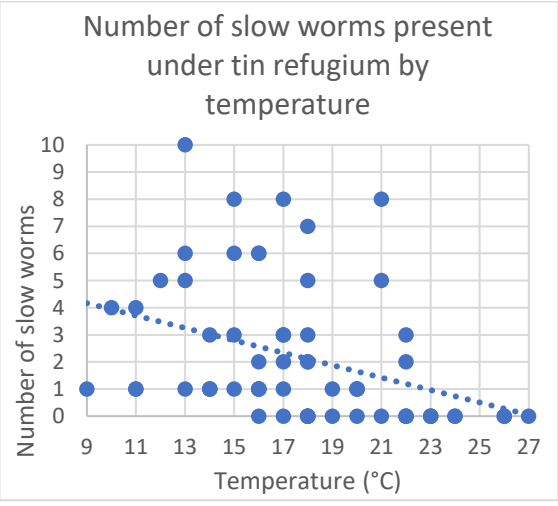
***Dark with white splots***
*Recorded x2 from 16th July*
*Snout-vent length c.70mm*
*Total body length c.140mm*

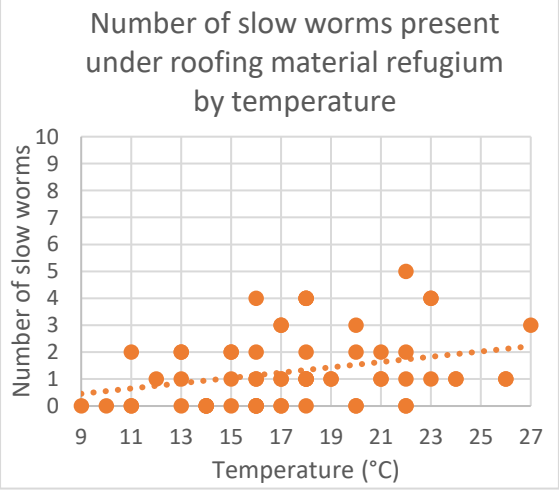
## Refugia use by temperature

At Cardiff University, two of the refugia (Refugium #1 and Refugium #2) are only a few metres apart. One of these refugia is made of corrugated tin, while the other is made of corrugated roofing material. Because the refugia are so close together, it has been easy to see patterns about when slow worms are under each one. At Cardiff University, based on the data from 94 surveys between 2018 and 2021, more slow worms tend to be found under tin refugium between 7-18°C and under the corrugated roofing material refugium between 19-24°C. This is especially noticeable at extremes of temperature. At 8-10°C slow worms were only seen under the corrugated tin refugium, and at 23-27°C slow worms were only seen under the corrugated roofing material refugium.




The Pearson's correlation coefficient for the graph shows the average number of slow worms found under the tin refugium and temperature is weakly positively correlated (r=0.4). There is also a moderate (r=-0.7) negative correlation between the average number of slow worms found under the roofing material refugium and temperature. But this version of the chart, which uses average number of slow worms seen under each refugium at different temperatures is a cleaned version of the full scatterplot graph which includes every single reference.




The correlation is weaker if we look at the full, messier data. Even if we reject the records of surveys where no slow worms were found under either of the refugia, the correlation between temperature and number of slow worms under the tin refugium only has a Pearman's correlation coefficient value of -0.4 (weak negative correlation) and the correlation between temperature and

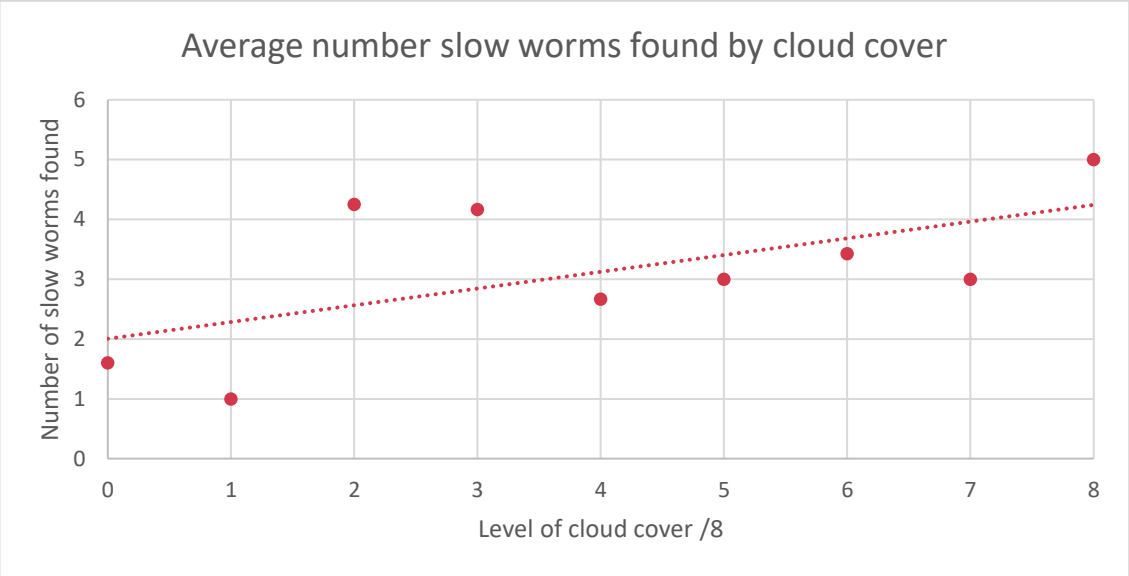
number of slow worms under the roofing material refugium has a correlation coefficient value of +0.3 (weak positive correlation). This appears to be because there are more extraneous variables, especially for the tin refugium records, so there is a high percentage of outlying data in the full table. However, all of the correlations are significant at $p \leq 0.05$.

At first sight, these charts appear to reflect slow worms making a choice between the two refugia based on material, with all slow worms choosing roofing material at 27°C and all slow worms choosing tin at 9°C, and a swap-over at 20°C. It is also worth noting that the tin refugium has much higher peak counts than the roofing material refugium, including thirteen surveys with five or more individuals present under the one refugium (this high a count has only been found under the roofing material refugium once). Slow worms are known to thermoregulate to some degree. This means they make active decisions about what to do in order to keep their bodies near an optimal temperature rather than just thermoconforming (Platenberg 1999). However, previous studies have suggested that slow worms do not show preference for refugia based on material (Fish 2016). An alternative explanation is that slow worms are making separate choices about whether to be under each refugium at any given temperature. For example, at 25°C it might be that slow worms simply choose not to bask under the tin refugium because it is too hot (as in Riddell 1996). That does not necessarily mean that the slow worms are choosing the roofing material refugium, perhaps they are just reacting to avoid (or minimise their time under) the tin refugium at high temperatures. These results essentially agree with Platenberg's (1999) findings that slow worms are generally only present at 24°C or under [presumably under tin refugia], and are most numerous under 20°C.

## Survey times

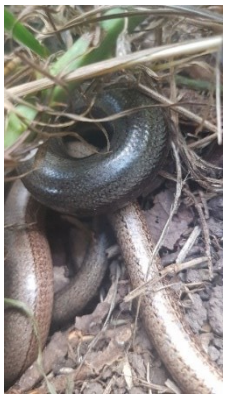
The most reliable time of day to survey seems to be late morning. Although generally reptiles are best surveyed in the morning, the slow worm area at Cardiff University is on a slope which does not receive much sunlight until the sun has properly risen. The statistics from our late morning surveys suggest that 90% of late morning surveys have been successful and the average count is five slow worms, although it should be noted that most of these surveys were carried out in 2018 and 2019, the most successful slow worm seasons, when I regularly had access to the site in late morning. After twelve noon, the average slow worm count does not differ much, and although early afternoon appears to be less successful (58%) than late afternoon (70%), this may be in part because most of the surveying in the very poor 2020 and 2021 seasons was carried out at this time of day. Surveys at this time in other years were more successful. This effect is likely to be due to biases in our data based on the time of day I surveyed most often during different years.

On some slow worm surveying sites, cloud cover has been found to affect the number of slow worms found (Smith 1990 p. 36). In order to see if this was the case at Cardiff University, I started noting the Okta cloud coverage on site in 2019. Based on data from 82 site visits where cloud cover was recorded, there is a slight increase in the average number of slow worms found at Cardiff University based on cloud cover. When there is no or almost no cloud cover, generally fewer slow worms are found than when there is any cloud cover or a great deal of cloud cover. We can see this most clearly by looking at a scatterplot of the average number of slow worms found under each different Okta cloud coverage score.




However, when looking at the raw data, there is only a negligible (0.1) positive correlation. Slow worm presence (rather than abundance) is even less correlated to cloud cover –the same % of surveys (63%) found slow worms present when there was absolutely no cloud cover (Okta score=0, 5 out of 8 surveys) and when there was cloud cover (Okta score 1-8, 46 out of 69 surveys). This follows the results found by Platenberg (1999). Anecdotally the greatest number of slow worms was seen in survey conditions of sunshine after rain, and the apparent cloud cover connection might be due to that.

## The Cardiff University slow worm calendar



The slow worm seasonal activity at Cardiff essentially agrees with that observed by Smith (1990). At Cardiff University slow worms are typically first recorded on site in March or early April. Jones (2009) found that slow worms in Wales often emerge from hibernation in February, but this has not yet been observed at Cardiff University. March is usually an unreliable survey month (slow worms are found only 31% of the time), not just because some slow worms may still be hibernating, but also because slow worms will return underground if it becomes too cold and wet. April is a far more reliable month (81% success rate), and the joint highest number of slow worms ever found on a single survey was April 25th, 2019, when twelve slow worms were found.

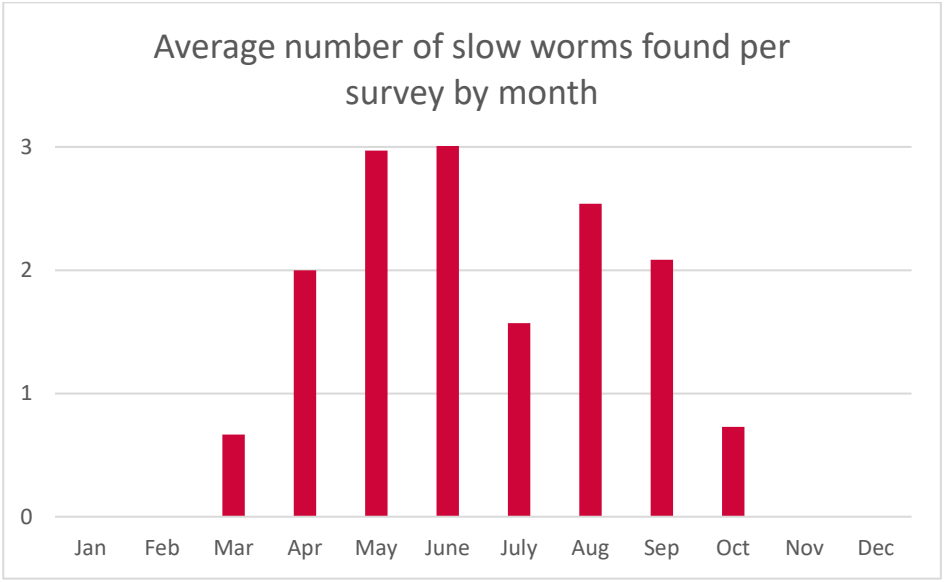
Early summer (May and June) are some of the most reliable months of the year (79%) for surveying slow worms (Beebee and Griffiths 2000 p. 117). The average count per survey in these months was 3, which is the highest it reaches all year. This is the time of year when slow worms mate (although note, not all slow worms will mate every year, in Britain, perhaps because of the colder climate, slow worms tend to mate only once every other year (Platenberg 1999)), and they tend to be most visible in these months. Surveys in these months rarely fail, except in the first week of May.

In July, although the reliability of the surveys falls only slightly (73%), there average count drops considerably below the count in June. This is not just an idiosyncrasy of our data, it has been noticed by other surveyors elsewhere in Britain (Natural England 2011 p. 25). When viewing the survey data as a line-graph, this causes a notable slump in the mid-season.

August and September are more reliable months, not in terms of reliability of survey (which stays at 73%) but in terms of higher counts. Along with May and June, August and September are where we typically find our peak numbers of slow worms present (the other joint equal highest number of slow worms found on a single survey was 29th August 2018 when twelve slow worms were found). This is in part due to the birth of the new juveniles, who are born in August and September each year.

October is second only to March as an unreliable month for surveying (69%). Our slow worms tend to return into hibernation in early-mid October (twice the final sighting has been on the 17th) slow worms are not commonly found in surveys in the second half of the month, however, the site needs to be surveyed anyway so that the yearly mow can be scheduled promptly after the slow worms are certainly absent – it is important that the mowing takes place before the grass collapses in winter if at all possible.

Cardiff University's slow worms have, as far as I know, never been recorded in the winter months (November-February). It is not clear if they hibernate on or off site.



# Recommendations

It is likely that 2021 will be the final year of the current slow worm survey at Cardiff University. However, there remain a few questions for further attention: The most important of these is:

- Was there a drop in population in 2020-2021, and if so, will the population drop further? If it is at all possible, the slow worm area needs to be checked at least four times a year (perhaps May, June, August, September). The slow worms don't necessarily need to be handled each time, but the number of slow worms found on each survey should be recorded on Record Pool (www.recordpool.org.uk) and if any slow worms are covered in mites or obviously injured this might require some remedial action. If the population disappears the negative surveys should also be recorded on Record Pool.

The answers to three other questions will help the *Ecosystem Resilience and Biodiversity Action Plan* steering committee properly target its resources:

- Are any other parts of Cardiff University (especially around the existing slow worm area) used by our slow worms? This could be checked by placing additional refugia in promising areas. How can we maximise the site's utility for slow worms?

- Do rats adversely affect the slow worm population at Cardiff University? This could be answered through a literature search and through bringing together present and historical rat control site data with our slow worm records. Surveying during future droughts might also help to confirm or deny the alternative explanation, that dry spells affect the slow worm population at Cardiff University.

- Is the ratio between peak count and abundance at Cardiff University stable? This could be answered by running another population survey once the peak count rises. If the answer is yes, the population can be monitored without needing to handle any more slow worms.

Finally, there are three questions which are not important for the conservation of the slow worms, but might help us understand Cardiff University's only reptiles better than we do now:

- Do Cardiff University's slow worms have a strategy to choose between Refugia #1 and #2 based on temperature, or do they just react to different temperatures? If the slow worms under each refugium are identified and tracked, it should be possible to at least conclude about whether slow worm individuals use both refugia, and, if so, whether their location is connected to the temperature.

- Since cloud cover does not seem to affect slow worms much, could a different weather variable be monitored? Perhaps a more useful weather type to survey would be ("has it rained in the last 24 hours?"). Cardiff University's slow worms seem to be especially active on bright afternoons after rainy mornings.

- How long do Cardiff University's slow worms live? There are reports of slow worms living 54 years in captivity, and many live ten to fifteen years even in the wild (Beebee and Griffiths 2000 p. 121). Future population surveys in years to come might find some of the slow worms described in this report, and it is likely that some/most of them are still growing.

# List of References

Beebee, T. J. C., and R. Griffiths. 2000. *Amphibians and reptiles*. Collins, London.

Beebee, T. J. C., and S. Ratcliffe. 2018. Inferring status changes of three widespread British reptiles from NBN Atlas records. *Herpetological Bulletin*(143):18–22.

Bruford, M., L. Baillie, A. S. Bellamy, J. Cuff, M. Davidova, K. Henderson, N. Hutchinson, C. James, J. Jenkins, J. Komar, S. Ormerod, L. Raye, M. Tercel, and A. Thompson. 2020. *Cardiff University Ecosystem Resilience and Biodiversity Action Plan 2021-2023*. Cardiff.

Christidis, N., P. Stott, and N. Kaye. 2021. Met Office: A review of the UK's climate in 2020. https://www.carbonbrief.org/met-office-a-review-of-the-uks-climate-in-2020.

Fish, A. 2016. Observations on felt and corrugated roof sheeting as materials for constructing coverboards to assess slow worm (Anguis fragilis) and common lizard (Zootoca vivipara) populations. *Herpetological Bulletin*(135):4–6.

Hails, E. L., and C. T. Strine. 2016. An "upside-down" juvenile slow-worm (Anguis fragilis): could this be a thermophilic behaviour. *The Herpetological Bulletin* 138:42.

JNCC. 2021. Quinquennial Review 7. https://jncc.gov.uk/our-work/qqr-7/.

Jones, R. 2009. British reptile conservation: phylogeography and translocation studies. Cardiff University.

Krebs, C. J. 2014. Estimating Abundance and Density: Mark-Recapture Techniques. Pages 20–77 *Ecological Methodology*. in prep.

National Drought Group. 2020. July 2020 statement. https://www.gov.uk/government/news/national-drought-group-july-2020-statement.

Natural England. 2011. *Reptile mitigation guidelines*. Sheffield.

Owen, E. 1887. *Welsh Folk-Lore*. Woodall, Misshall, and Co., Wrexham.

Platenberg, R. J. 1999. Population ecology and conservation of the slow-worm Anguis fragilis in Kent. University of Kent.

Prestt, I., A. S. Cooke, and K. F. Corbett. 1974. British amphibians and reptiles. Pages 229–254 *in* D. L. Hawksworth, editor. *The changing flora and fauna of Britain*. Published for the Systematics Association by Academic Press, London.

Riddell, A. 1996. Monitoring slow-worms and common lizards, with special reference to refugia material, refugia occupancy and individual indentification. Pages 46–60 *in* J. Foster and T. Gent, editors. *Reptile survey methods: proceedings of a seminar held on 7 November 1995 at the Zoological Society of London's meeting rooms, Regent's Park, London*. English Nature Science no 27, London.

Riddell, A. 1997. Identifying individuals - which slow worm is which. Pages 15–16 *in* A. Riddell, editor. *The Slow-worm*. Kent Reptile & Amphibian Group, Kent.

Schmidt, B. R., A. Meier, C. Sutherland, and J. Royle Andy. 2019. Spatial capture–recapture analysis of artificial cover board survey data reveals small scale spatial variation in slow-worm Anguis fragilis density. *Royal Society Open Science* 4(9):170374.

Smith, N. D. 1990. The ecology of the slow-worm (Anguis fragilis L.) in southern England. University of Southampton.

## Appendix: survey results

| Date | Time Start | Time Left | Weather | Approx temp °C | Total | Tin | Roofing | Refugium 3 |
|---|---|---|---|---|---|---|---|---|
| 4 May-16 | 14:30 | 15:00 | sunny, hot | | 1 | 1 | | |
| 11 Jun-16 | 19:00 | 19:30 | clear, warm | | 1 | 1 | | |
| 23 Jun-16 | 19:30 | 20:00 | cloudy, warm | | 1 | 1 | | |
| 15 Jul-16 | 12:00 | 12:30 | drizzle | | 4 | 4 | | |
| 30 Jul-16 | 21:00 | 21:15 | just getting dark | | | | | |
| 17 Aug-16 | 14:30 | 15:00 | cloudy, warm | | 1 | 1 | | |
| 24 Aug-16 | 14:30 | 15:00 | hot, clear | | 6 | 6 | | |
| 09 Sep-16 | 16:15 | 16:45 | hot, cloudy | | 1 | 1 | | |
| 14 Sep-16 | 15:00 | 15:15 | hot, clear | | 5 | 5 | | |
| 21 Sep-16 | 15:00 | 15:15 | warm, cloudy | | 4 | 4 | | |
| 30 Sep-16 | 15:15 | 15:30 | drizzle | | 1 | 1 | | |
| 03 Oct-16 | 15:00 | 15:30 | sunny, clear | | 3 | 3 | | |
| 12 Oct-16 | 15:00 | 15:15 | sunny, warm | | 0 | 0 | | |
| 17 Oct-16 | 15:15 | 15:30 | warm, wet | | 1 | 1 | | |
| 26 Oct-16 | 15:00 | 15:30 | warm, wet | | 0 | 0 | | |
| 31 Mar-17 | 11:00 | 11:45 | sunny, clear | | 2 | 2 | | |
| 06 Apr-17 | 16:30 | 17:00 | sunny, clear | | 1 | 1 | | |
| 11 Apr-17 | 08:45 | 12:00 | sunny, hot | | 1 | 1 | | |
| 14 Apr-17 | 16:00 | 16:30 | warm, cloudy | | 4 | 4 | | |
| 24 Apr-17 | 14:00 | 14:30 | warm, cloudy | | 4 | 4 | | |
| 27 Apr-17 | 16:00 | 16:30 | warm, clear | | 1 | 1 | | |
| 02 May-17 | 11:00 | 11:30 | warm, clear | | 3 | 3 | | |
| 05 May-17 | 15:00 | 15:30 | hot, sunny | | 0 | 0 | | |
| 13 May-17 | 18:00 | 18:30 | warm, sunny | | 4 | 4 | | |
| 19 May-17 | 17:00 | 17:30 | warm, sunny | | 2 | 2 | | |
| 28 May-17 | 19:00 | 19:30 | cloudy, cool | | 2 | 2 | | |
| 04 Jun-17 | 09:00 | 09:30 | warm, sunny | | 8 | 8 | | |
| 21 Jun-17 | 14:00 | 16:00 | sunny, v. hot | | 0 | 0 | | |
| 25 Jun-17 | 16:00 | 16:30 | warm, overcast | | 3 | 3 | | |
| 30 Jun-17 | 15:00 | 15:30 | sunny, v. hot | | 0 | 0 | | |
| 15 Jul-17 | 13:00 | 13:30 | warm, overcast | | 6 | 6 | | |
| 04 Aug-17 | 15:00 | 15:15 | warm, wet spells | | 0 | 0 | | |
| 09 Aug-17 | 15:00 | 15:15 | sunny, hot, wet spells | | 0 | 0 | | |
| 16 Aug-17 | 15:00 | 15:15 | warm, overcast | | 1 | 1 | | |
| 16 Aug-17 | 15:00 | 15:15 | warm, overcast | | 0 | 0 | | |
| 21 Aug-17 | 15:00 | 15:30 | sunny, warm | | 0 | 0 | | |

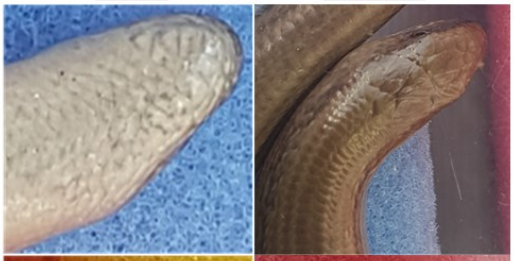
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 25 Aug-17 | 18:00 | 18:30 | sunny, hot | | 0 | 0 | | |
| 30 Aug-17 | 16:00 | 16:30 | sunny, warm | | 2 | 0 | 1 | 1 |
| 07 Sep-17 | 15:00 | 15:30 | warm, overcast | | 3 | 0 | 2 | 1 |
| 18 Sep-17 | 15:00 | 15:30 | overcast | | 0 | 0 | 0 | 0 |
| 25 Sep-17 | 15:00 | 15:30 | rainy spells, warm | | 0 | 0 | 0 | 0 |
| 04 Oct-17 | 15:00 | 15:30 | dry, warm | | 0 | 0 | 0 | 0 |
| 28 Feb-18 | 15:00 | 15:30 | cold, clear | | 0 | 0 | 0 | 0 |
| 07 Mar-18 | 15:00 | 15:30 | warm, clear | | 0 | 0 | 0 | 0 |
| 14 Mar-18 | 15:00 | 15:30 | overcast, cool | | 0 | 0 | 0 | 0 |
| 21 Mar-18 | 16:00 | 16:30 | overcast, cool | | 0 | 0 | 0 | 0 |
| 04 Apr-18 | 15:00 | 15:30 | warm, clear | | 1 | 1 | 0 | 0 |
| 11 Apr-18 | 16:00 | 16:30 | overcast, cool | | 0 | 0 | 0 | 0 |
| 16 Apr-18 | 14:00 | 14:30 | cloudy, warm | | 2 | 1 | 0 | 0 |
| 25 Apr-18 | 15:00 | 15:30 | sunny, warm, windy | | 7 | 4 | 2 | 1 |
| 06 May-18 | 12:30 | 13:00 | sunny, hot, still | | 8 | 4 | 3 | 1 |
| 12 May-18 | 17:00 | 17:30 | overcast, cool | | 6 | 3 | 3 | 0 |
| 16 May-18 | 15:00 | 15:30 | warm, clear | | 5 | 2 | 3 | 0 |
| 23 May-18 | 14:30 | 15:00 | too hot | | 0 | 0 | 0 | 0 |
| 10 Jun-18 | 19:45 | 20:15 | warm but evening | | 6 | 3 | 2 | 1 |
| 27 Jun-18 | 15:00 | 15:15 | | | 1 | 0 | 1 | 0 |
| 11 Jul-18 | 14:45 | 15:15 | warm, clear | | 1 | 0 | 1 | 0 |
| 18 Jul-18 | 15:00 | 15:30 | warm, clear | | 2 | 0 | 2 | 0 |
| 24 Jul-18 | 15:00 | 15:30 | cool | 19 | 2 | 0 | 1 | 1 |
| 03 Aug-18 | 14:00 | 14:30 | warm, clear | 22 | 5 | 0 | 5 | 0 |
| 10 Aug-18 | 18:00 | 18:30 | cool | 17 | 0 | 0 | 0 | 0 |
| 14 Aug-18 | 11:30 | 12:00 | warm | 20 | 5 | 1 | 3 | 1 |
| 22 Aug-18 | 11:30 | 12:00 | cool, showers | 17 | 11 | 8 | 3 | 0 |
| 29 Aug-18 | 11:30 | 12:00 | sunny, cool | 15 | 12 | 8 | 2 | 2 |
| 05 Sep-18 | 15:30 | 16:00 | | | 6 | 2 | 2 | 2 |
| 14 Sep-18 | 15:00 | 15:30 | cool | 16 | 2 | 2 | 0 | 0 |
| 19 Sep-18 | 11:30 | 12:00 | sunny | 21 | 10 | 8 | 1 | 1 |
| 26 Sep-18 | 11:30 | 12:00 | cool | 17 | 2 | 2 | 0 | 0 |
| 03 Oct-18 | 11:30 | 12:00 | damp, sunny | 14 | 3 | 3 | 0 | 0 |
| 10 Oct-18 | 10:30 | 11:00 | damp, cloudy | 16 | 1 | 1 | 0 | 0 |
| 17-Oct-18 | 11:30 | 12:00 | Okta cloud cover | 16 | 1 | 1 | 0 | 0 |
| 11 Mar-19 | 11:30 | 12:00 | 3 | 9 | 1 | 1 | 0 | 0 |
| 18 Mar-19 | 15:40 | 16:00 | 7 | 11 | 1 | 1 | 0 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 23 Mar-19 | 16:00 | 16:30 | 7 | 11 | 4 | 4 | 0 | 0 |
| 01 Apr-19 | 16:45 | 17:00 | 0 | 13 | 1 | 1 | 0 | 0 |
| 08 Apr-19 | 14:15 | 14:30 | 6 | 10 | 4 | 4 | 0 | 0 |
| 19 Apr-19 | 16:45 | 17:10 | 0 | 22 | 3 | 3 | 0 | 0 |
| 25 Apr-19 | 11:45 | 12:10 | 8 | 13 | 12 | 10 | 2 | 0 |
| 28 Apr-19 | 16:55 | 17:15 | 8 | 13 | 8 | 6 | 2 | 0 |
| 04 May-19 | 16:50 | 17:05 | 2 | 13 | 6 | 5 | 1 | 0 |
| 11 May-19 | 17:00 | 17:30 | 5 | 16 | 7 | 6 | 1 | 0 |
| 17 May-19 | 13:15 | 13:30 | 8 | 12 | 7 | 5 | 1 | 1 |
| 24 May-19 | 13:15 | 13:45 | 7 | 18 | 9 | 5 | 4 | 0 |
| 30 May-19 | 11:30 | 12:00 | 6 | 16 | 11 | 6 | 4 | 1 |
| 08 Jun-19 | 14:15 | 14:45 | 4 | 15 | 7 | 6 | 1 | 0 |
| 12 Jun-19 | 16:00 | 16:30 | 8 | 15 | 5 | 3 | 2 | 0 |
| 20 Jun-19 | 11:40 | 12:00 | 3 | 18 | 11 | 7 | 4 | 0 |
| 05 Jul-19 | 12:30 | 13:00 | 4 | 22 | 2 | 0 | 1 | 1 |
| 12 Jul-19 | 10:45 | 11:00 | 2 | 21 | 6 | 5 | 1 | 0 |
| 17 Jul-19 | 14:15 | 14:30 | 3 | 23 | 0 | 0 | 0 | 0 |
| 27 Jul-19 | 17:45 | 18:00 | 8 | 20 | 1 | 1 | 0 | 0 |
| 03 Aug-19 | 13:00 | 13:15 | 8 | 21 | 0 | 0 | 0 | 0 |
| 08 Aug-19 | 14:45 | 15:00 | 7 | 22 | 2 | 0 | 2 | 0 |
| 15 Aug-19 | 11:35 | 11:55 | 7 | 18 | 2 | 0 | 2 | 0 |
| 19 Aug-19 | 15:15 | 15:35 | 3 | 18 | 4 | 0 | 4 | 0 |
| 25 Aug-19 | 15:15 | 15:40 | 0 | 24 | 1 | 0 | 1 | 0 |
| 02 Sep-19 | 12:40 | 13:00 | 8 | 17 | 0 | 0 | 0 | 0 |
| 07 Sep-19 | 16:25 | 16:40 | 7 | 18 | 4 | 2 | 1 | 1 |
| 13 Sep-19 | 13:15 | 13:35 | 0 | 18 | 2 | 0 | 1 | 1 |
| 20 Sep-19 | 13:15 | 13:25 | 0 | 18 | 0 | 0 | 0 | 0 |
| 27 Sep-19 | 14:00 | 14:25 | 7 | 16 | 1 | 1 | 0 | 0 |
| 03 Oct-19 | 13:45 | 14:10 | 8 | 14 | 1 | 1 | 0 | 0 |
| 16 Oct-19 | 13:30 | 13:50 | 4 | 15 | 0 | 0 | 0 | 0 |
| 17 Oct-19 | 13:55 | 14:10 | 3 | 14 | 0 | 0 | 0 | 0 |
| 05 Feb-20 | 14:00 | 14:10 | 1 | 9 | 0 | 0 | 0 | 0 |
| 27 Feb-20 | 11:45 | 12:15 | 1 | 6 | 0 | 0 | 0 | 0 |
| 06 Mar-20 | 14:00 | 14:15 | 6 | 8 | 0 | 0 | 0 | 0 |
| 15 Mar-20 | 16:00 | 16:15 | 2 | 10 | 0 | 0 | 0 | 0 |
| 17 Mar-20 | 13:00 | 13:30 | 8 | 11 | 0 | 0 | 0 | 0 |
| 23 Mar-20 | 14:15 | 14:40 | 0 | 11 | 0 | 0 | 0 | 0 |
| 22 Jun-20 | 13:15 | 13:50 | 7 | 19 | 0 | 0 | 0 | 0 |
| 29 Jun-20 | 13:00 | 13:15 | 8 | 15 | 0 | 0 | 0 | / |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 06 Jul-20 | 13:00 | 13:45 | 5 | 16 | 1 | 0 | 1 | 0 |
| 13 Jul-20 | 12:15 | 12:30 | 8 | 17 | 0 | 0 | 0 | 0 |
| 20 Jul-20 | 12:30 | 13:15 | 5 | 18 | 0 | 0 | 0 | 0 |
| 27 Jul-20 | 13:20 | 13:35 | 8 | 18 | 0 | 0 | 0 | 0 |
| 03 Aug-20 | 13:30 | 13:45 | 6 | 19 | 0 | 0 | 0 | 0 |
| 10 Aug-20 | 13:15 | 13:45 | 8 | 24 | 1 | 0 | 1 | 0 |
| 24 Aug-20 | 13:15 | 14:00 | 5 | 20 | 2 | 0 | 2 | 0 |
| 01 Sep-20 | 13:20 | 13:40 | 6 | 17 | 1 | 0 | 1 | 0 |
| 05 Sep-20 | 15:15 | 15:35 | 4 | 18 | 1 | 0 | 1 | 0 |
| 14 Sep-20 | 14:20 | 14:35 | 0 | 23 | 1 | 0 | 1 | 0 |
| 21 Sep-20 | 13:30 | 13:45 | 0 | 18 | 0 | 0 | 0 | 0 |
| 25 Sep-20 | 14:00 | 14:25 | 6 | 15 | 0 | 0 | 0 | 0 |
| 05 Oct-20 | 14:00 | 14:30 | 7 | 14 | 0 | 0 | 0 | 0 |
| 10 Oct-20 | 15:30 | 15:45 | 2 | 14 | 1 | 1 | 0 | 0 |
| 17 Oct-20 | 14:45 | 00:00 | 8 | 11 | 0 | 0 | 0 | 0 |
| 22 Mar-21 | 13:50 | 14:10 | 7 | 12 | 0 | 0 | 0 | 0 |
| 29 Mar-21 | 13:10 | 13:28 | 8 | 13 | 0 | 0 | 0 | 0 |
| 06 Apr-21 | 11:45 | 12:15 | 7 | 6 | 0 | 0 | 0 | 0 |
| 23 Apr-21 | 13:20 | 13:35 | 1 | 17 | 0 | 0 | 0 | 0 |
| 07 May-21 | 13:25 | 13:40 | 2 | 13 | 0 | 0 | 0 | 0 |
| 10 May-21 | 14:40 | 15:00 | 4 | 15 | 1 | 1 | 0 | 0 |
| 17 May-21 | 14:25 | 14:40 | 7 | 14 | 1 | 1 | 0 | 0 |
| 24 May-21 | 13:10 | 13:40 | 4 | 11 | 3 | 1 | 2 | 0 |
| 31 May-21 | 17:15 | 17:45 | 4 | 22 | 2 | 2 | 0 | 0 |
| 16 Jun-21 | 13:30 | 14:00 | 2 | 23 | 4 | 0 | 4 | 0 |
| 25 Jun-21 | 13:15 | 13:40 | 7 | 16 | 3 | 1 | 2 | stopped checking |
| 02 Jul-21 | 13:10 | 13:25 | 6 | 21 | 2 | 0 | 2 | |
| 12 Jul-21 | 14:40 | 15:10 | 8 | 17 | 6 | 3 | 3 | |
| 14 Jul-21 | 14:15 | 14:45 | 3 | 23 | 4 | 0 | 4 | |
| 16 Jul-21 | 13:15 | 13:30 | 3 | 27 | 3 | 0 | 3 | |
| 19 Jul-21 | 13:15 | 13:30 | 1 | 26 | 1 | 0 | 1 | |
| 21 Jul-21 | 13:15 | 13:30 | 1 | 26 | 1 | 0 | 1 | |
| 23 Jul-21 | 13:15 | 13:30 | 4 | 25 | 0 | 0 | 0 | |
| 26 Jul-21 | 13:15 | 13:25 | 4 | 23 | 0 | 0 | 0 | |
| 28 Jul-21 | 13:15 | 13:45 | 6 | 17 | 2 | 1 | 1 | |
| 02 Aug-21 | 13:15 | 13:50 | 8 | 18 | 4 | 3 | 1 | |
| 04 Aug-21 | 13:20 | 13:35 | 6 | 20 | 1 | 1 | 0 | |
| 06 Aug-21 | 13:20 | 13:35 | 5 | 19 | 2 | 1 | 1 | |
| 09 Aug-21 | 07:40 | 07:50 | 1 | 14 | 0 | 0 | 0 | |
| 11 Aug-21 | 10:50 | 11:05 | 6 | 17 | 3 | 3 | 0 | |
| 13 Aug-21 | 17:05 | 17:25 | 3 | 18 | 2 | 2 | 0 | |

## Cardiff University Slow Worm Population Survey July-August 2021

Chin IDs | Parietal IDs

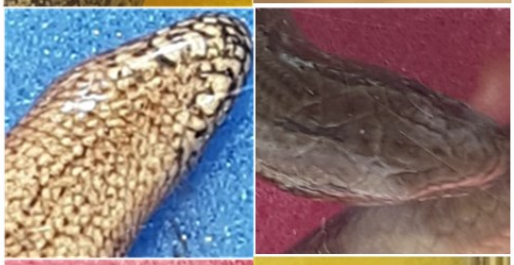


***Pale with herringbone marks***
*Recorded x1 from 14th July*
*Snout-vent length c.130mm*
*Total body length c.240mm*

***Pale with flicked fork***
*Recorded x2 from 2nd August*
*Snout-vent length c.120mm*
*Total body length c.140mm*

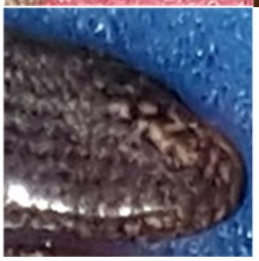
***Speckled***
*Recorded x2 from 2nd August*
*Snout-vent length c.120mm*
*Total body length c.230mm*

***Yellow spot and blue splodge***
*Recorded x6 from 14th July*
*Snout-vent length c.150mm*
*Total body length c.260mm*



***Pale hearts***
*Recorded x1 from 21st July*
*Snout-vent length c.130mm*
*Total body length c.290mm*

***Pale spots***
*Recorded x3 from 16th July*
*Snout-vent length c.90mm,*
*Total body length c.190mm*



***Dark with white splots***
*Recorded x2 from 16th July*
*Snout-vent length c.70mm*
*Total body length c.140mm*