Environmental factors and the distribution of reptiles at Lye Valley, Oxford

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Summary

This paper reports on a study undertaken in the Lye Valley, Oxford, to understand some of the environmental variables which affect reptile populations and thus know better how to conserve them.

Introduction

Reptiles are ectothermic animals which rely on external heat sources in order to reach their preferred body temperature, move around and digest their food. As many body functions are dependent on temperature, this means that reptiles have to regulate their behaviour to maintain the right temperature and if in a particular environment they are unable to do so they will be unable to survive. Reptiles obtain heat from their surroundings by a variety of mechanisms, including:

- absorbing radiation directly from the sun
- conduction from the surface on which they are resting
- convection from the surrounding air
- infrared energy absorbed from surrounding objects such as rocks

They do this by activities such as basking in the sun. The external environment also influences reptiles in other ways by providing areas of refuge from predators and affecting the ease with which they can find prey. For example, the grass snake feeds predominantly on amphibians, while 70% of the prey of slow worms consists of molluscs and earth worms in the soil (Beebee and Griffiths, 2000). Because of the importance of the external environment for maintaining body temperature, it clearly has a very important influence on reptile distribution and the purpose of this study is to determine how it affects reptiles found at Lye Valley.

Objectives

The objective was to undertake a quantitative assessment of the distribution of slow worm, common lizard and grass snake at Lye Valley and the influence of selected environmental variables on this distribution.

Research Question

What is the influence of key environmental variables on reptile distribution at Lye Valley? The factors considered include:

- Topography/aspect; (direction and gradient)
- Temperature and other weather conditions e.g. sun, wind, rain
- Shade/light level
- Vegetation type (based on key vegetation characteristics)
- Vegetation height (measured on each side of reptile survey mat)
- Whether the area is managed
- Wetness of ground/humidity

Subsidiary aims

The research also had the aim of establishing the size of the reptile population, its degree of isolation and of making recommendations to assist its future expansion.

Reptiles in Britain

It is often thought that reptiles must have ranges restricted to relatively warm areas, and that Britain is on the edge of reptiles' ranges. This is true of three of the British reptiles, namely the smooth snake; grass snake and sand lizard. However, it is not true of the slow worm, viviparous lizard or adder. The ranges of the latter two species even extend within the Arctic Circle (Beebee and Griffiths, 2000). In terms of environmental conditions these species are not therefore at the limit of their range. They are adapted to live in cooler conditions and in some cases are unable to live where the climate is hot. Both the adder and viviparous lizard occur in central and northern Europe and in the south of their range are confined to mountainous areas, with the adder being absent from most parts of Switzerland below 1,000 m (Guisan and Hofer, 2003). Indeed both these animals can live in sub-Arctic conditions where many other animals and trees are unable to survive.

Adaptation to living in a cool climate includes giving birth to live young rather than laying eggs, which applies to the adder, viviparous lizard, slow worm and smooth snake. The grass snake is unusual among snakes in laying eggs in decomposing organic matter, which provides warmth enabling the eggs to hatch in cool weather conditions (Beebee and Griffiths, 2000).

The viviparous lizard has a number of other adaptations to a cold climate. For example, the Biological Station of Franche Comte University found that viviparous lizards at Bonnevaux in the Doubs department in Eastern France were able to survive cold periods in a frozen or super-cooled state (Grenot *et al*., 2000). They have been found hibernating in burrows where the minimum and maximum temperature in January averaged 6 -1 °C. Despite this they had high survival rates (88 -100%) even in severe winters (Constanzo *et al*., 1995). Females also need to hibernate at temperatures below 8 – 10 °C for several weeks and if this does not occur they will not breed successfully the following spring, because their eggs do not develop (Beebee & Griffiths, 2000). The viviparous lizard is able to survive on less food than some other lizards and in addition to decrease the amount of food required by maintaining a lower body temperature. For example, it maintains its body temperature 3.4 °C lower than the European wall lizard, which means that it requires only 42% of the food needed by the wall lizard. This is of crucial importance in enabling the viviparous lizard to survive in a cool, cloudy climate as in the UK. Avery (in Frazer 1983, p162) calculated that on sunny days the body temperature of the viviparous lizard remained high enough for it to hunt food for five hours, but on changeable days this reduced to half an hour. This can mean that in some years the lizards are unable to feed on a majority of days. For example, in 1969 there were 132 sunny days; 42 changeable ones and 191 which were too dull for the lizards to feed (Frazer, 1983). The viviparous lizard is even able to live in very dull areas such as up to 1,000 m in the mountains of Scotland and Wales (Beebee and Griffiths, 2000). These adaptations have enabled the viviparous lizard to become one of the most widely distributed reptiles in the world extending from Ireland in the west, across Asia to Sakhalin island off the east coast of Russia (Grenot *et al*., 2000).

In the Lye Valley there are three reptiles, slow worm, viviparous lizard and grass snake, (figures 1 to 5, all by Stephen Pickles).

Figure 1. Female slow worm, dark brown sides and vertical stripe

Figure 2. At least six slow worms counted from their heads

Figure 3. Female viviparous lizard

Figure 4. Female viviparous lizard that had lost its tail

Figure 5. Grass Snake

The smooth snake and sand lizard do not occur in Oxfordshire, while the adder is nearly extinct (D'Ayala, pers. comm.) The European and local distribution of these species are shown in figures 6 to 8. While both the viviparous lizard and slow worm are widely distributed, much of Britain consists of arable fields, heavily grazed pastures and dense woodland, which are all unsuitable, so their distribution is very patchy. The grass snake is rare in northern England and absent from Scotland.

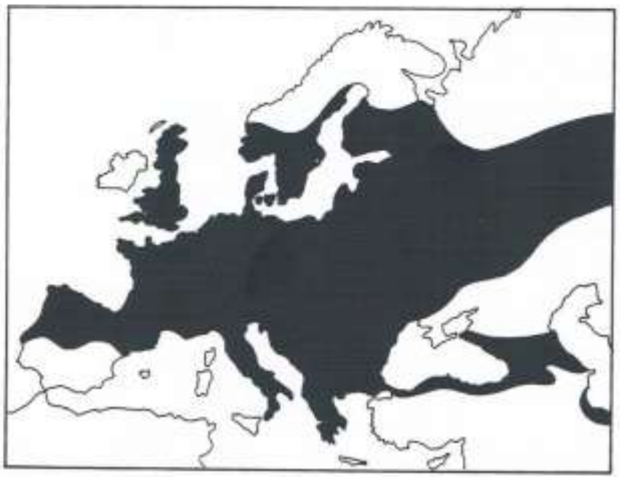

Figure 6. Slow Worm; European distribution above and British distribution right (Beebee and Griffiths, 2000)

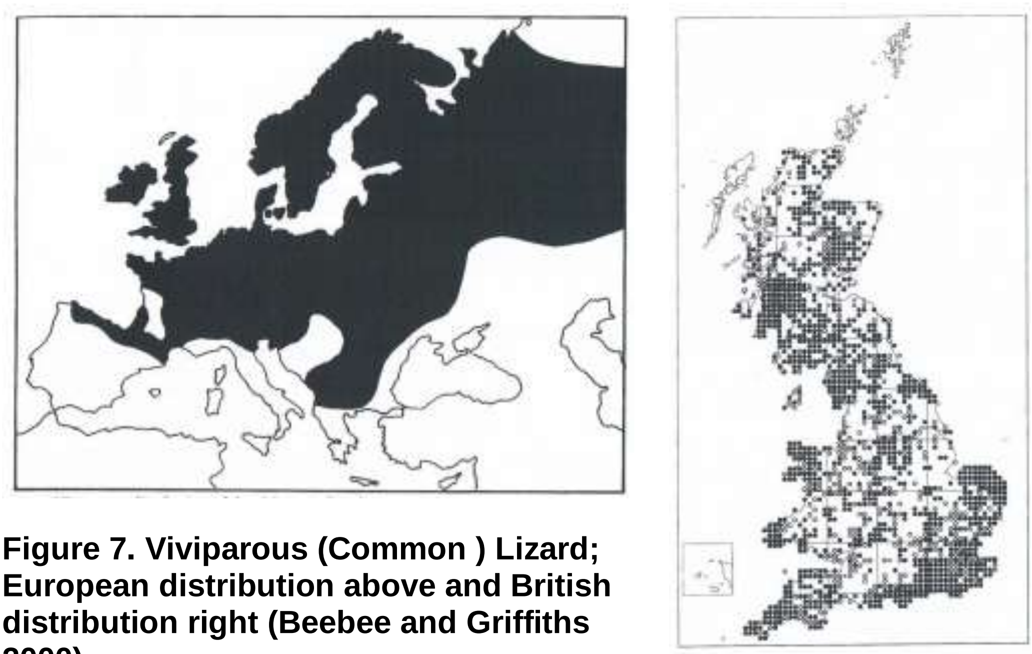

Figure 7. Viviparous (Common) Lizard; European distribution above and British distribution right (Beebee and Griffiths 2000)

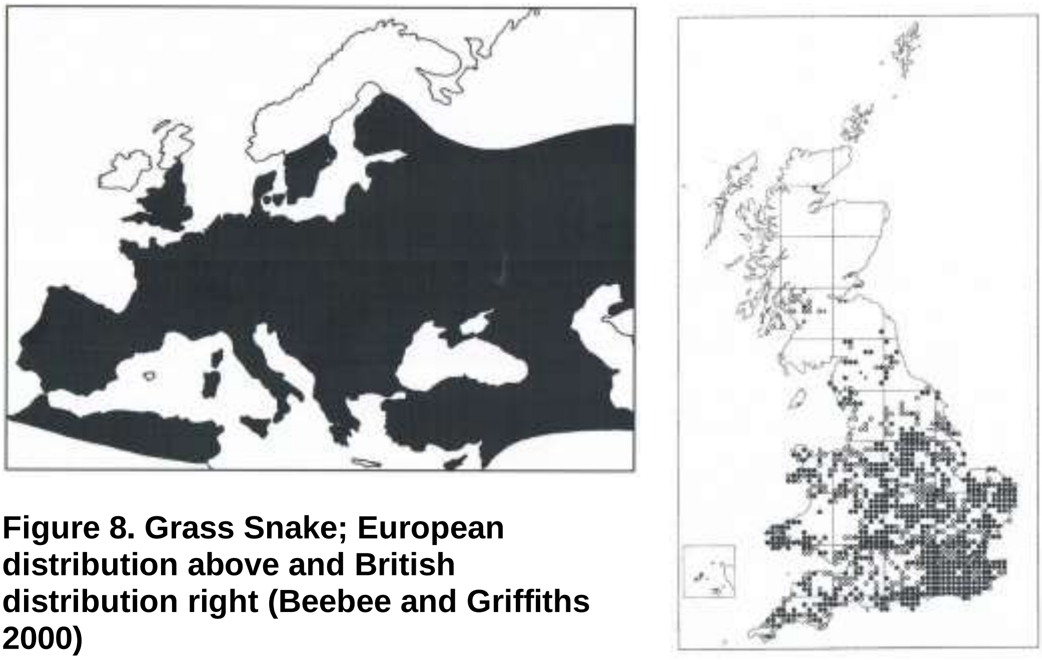

Figure 8. Grass Snake; European distribution above and British distribution right (Beebee and Griffiths 2000)

Study site and previous reptile studies

The study area consisted of the Lye Valley and Boundary Brook corridors in east Oxford (figure 9). This area contains a variety of habitats and thus provided a good opportunity to assess the influence of environmental factors on reptile populations. There have been two previous reptile surveys which covered a very small part of this area. In 2005 Martin Townsend undertook a reptile survey of the fen habitat at Lye valley north using 12 survey mats. In four visits he recorded one common lizard (D'Ayala and Townsend, 2005). In 2007 a reptile survey of Oxford Golf Course using 55 mats did not record any reptiles (Baker et al., 2007).

Figure 9. Location of reptile survey mats

However, Judy Webb reported viviparous lizard basking on willow at Lye Valley fen (J. Webb, pers. comm.). She also sent records from Steve Woolliams, of grass snake, slow worm and viviparous lizard on 'the triangle' above north fen (SP54701 05856 and SP54697 05851) (J. Webb, pers. comm.). Allotment holders at Town Furze allotments at the head of Lye Valley report seeing slow worms in their compost heaps and local residents report cats bringing back grass snakes.

Research methods

The reptile population was assessed by putting down 80 pieces of roofing felt 1 m x 50 cm, which is the recommended size (Froglife, 1999). The habitats where the mats were placed are described in table 1 and locations shown in figure 9. The intention was to put two lots of five mats in each habitat type but in different locations, so that comparisons could be made. Adjustments had to be made as an area adjoining the southern fen proved to be outside the area where I had permission to work. This resulted in a total of 15 mats being located in open fen and only five in tall herb habitat.

Table 1. Habitats where 80 reptile survey mats were located

	Habitat type	Mat position and mat numbers
1	Grassland (10 mats)	5 mats S of Churchill Hospital on plateau gently sloping S (mats 56 – 60)
		5 mats on slope facing NE at Oxford golf course (mats 76- 80)
2	Lightly shaded woodland/scrub (10 mats)	5 mats adjoining Lye Brook on flat ground and slope facing SE (mats 66 -70)
		5 mats in lightly shaded woodland adjoining Boundary Brook on flat ground and slope facing SW (mats 71– 75)
3	Dense woodland/scrub, where there is ground vegetation (10 mats)	5 mats on E side of Lye Brook on valley side that faces NW (mats 11 - 15)
		5 mats in on W side of Lye Brook on valley side that faces SE (mats 16 -20)
4	Dense Reed (10 mats)	5 mats E side of Lye Brook on flat ground at S end of the northern part of Lye Valley SSSI (mats 26 -30)
		5 mats on the W side of Lye Brook on a slope facing SE, immediately opposite those under 4 i) and within the N part of Lye Valley SSSI (mats 31 – 35)
5	Open reed/edge of open fen (15 mats)	5 mats in open fen at the northern part of the Lye Valley SSSI (due to vegetation growth and their location at the edge of the fen, this became dense by the end of the survey) (mats 21 –25)
		10 mats in open reed/sedge at the southern part of Lye Valley SSSI adjoining Oxford golf course (mats 36– 45)
6	Edge of two habitats, grassland/bramble/line of trees (10 mats)	5 mats at N boundary of grassland S of Churchill hospital where it adjoins an area of bramble/nettles (mats 51 – 55)
		5 mats on grassland S of Warren Crescent, S of a row of field maple. (on the N side of an area of bramble/nettles and so is between trees and tall herb/bramble) (mats 46-50)
7	Tall herb (5 mats)	5 mats on slope S of Fulbrook Centre where vegetation consists of nettle, Himalayan balsam, convolvulus and grass (mats 61 – 65)
8	Allotments (10 mats)	All 10 mats on the Town Furze allotments (mats 1 -10)

Where possible the mats were put in different aspects/topography in each of the habitats. The mats were located in clusters about 10 m apart, although this was not always possible, due to obstacles such as allotment equipment/plots, or the desire to sample varying environmental characteristics within each habitat. The environmental information that was recorded for each survey location in order to test the research hypotheses is detailed in table 2 below.

Table 2. Environmental data recorded at Lye Valley as part of the reptile survey

1	Aspect (direction that mat is facing)	Recorded using a reading from a Silva compass
2	Topography	The angle of the slope of the mat was recorded by attaching a protractor to a spirit level with string. The protractor was then placed on the mat and the spirit level held level. The angle of the string between the two was measured against the protractor
3	Air Temperature	A variety of temperature readings were recorded. On the first survey temperature was recorded 1 m above the mat level. However, on reflection it was considered that a reading within 5 cm of ground level would be more representative of the conditions where reptiles live, so this was used in subsequent surveys.
		The temperature was taken using a multimetre. The readings seemed to be somewhat high and this suspicion was strengthened on the last two surveys when readings were also taken of the mat surface using an infrared thermometer and the air temperature readings given were not infrequently higher than those of the mat surface, despite this being black.
4	Ground temperature	Recorded using a probe 5 cm long inserted into the ground, on 16 June 2012; 23 June 2012; 30 June 2012; and 7 July 2012.
5	Mat temperature	An infrared thermometer was used to measure the temperature of the top of the mat on 11.7.12 and 14.7.12.
6	Vegetation temperature surrounding the mat	Recorded using the infrared thermometer.
		On 11.7.12 four readings were taken on each side of the mat. On 14.7.12 one reading was taken near the mat.

7	Relative Humidity	Recorded using the multimetre. Due to changing weather the readings frequently reflect these changes rather than variations between habitat type. For example, on several survey days there were showers and after these the multimetre normally recorded 100% humidity for some time afterwards. Relative humidity was recorded in all surveys.
8	Wetness of soil	Determined by feeling the soil, if it was not immediately apparent from the presence of water at or near the surface. The categories used were dry, slightly moist, moist, very moist, saturated and water on surface. Dry soil was also determined by the colour of the soil.
9	Light	Recorded using the multimetre in Lux. The figures recorded up to 19,999. For all readings above this in very bright conditions the multimetre gives the score 1. When this occurred the light was recorded as 20,000 as it had reached at least this level.
10	Habitat type	Key vegetation characteristics.
11	Vegetation height	Recorded, on the 16.6.12 and the 7.7.12. It was difficult to give a figure that accurately indicated the vegetation height around each of the mats. A number of the mats were in woodland. Around some mats (particularly those in woodland) there was also a substantial amount of bare ground so giving the height of the hedge parsley/nettles/ground elder which was also present would give a misleading impression. There was also often a substantial range in the height of the vegetation around a mat, particularly when the mat was on the boundary between two habitats. For these reasons a range has often been given
12	Whether the area is managed	During the survey period the only locations where there was any evidence of management was at Town Furze allotments, where this takes place on almost a daily basis and the north and south fens where some, but not all of the tall reed was cut at the beginning of July, with a view to encouraging rare fenland plants. The five mats on Southfield golf course adjoin an area that is intensively managed, though the bank where the survey mats were placed was not cut during the survey period. The other locations, including the two grassland areas gave no evidence of management.

Eighty mats were laid out on 2nd June and the first survey undertaken on 16th June, as mats should be left for at least two weeks before the survey (Froglife 1999).

A significant factor in evaluating the likely effectiveness of refuges is their ability to attract reptiles. English Nature undertook a three year survey using artificial refuges in Dorset. Each year each refuge was checked between 25 and 28 times by surveyors walking a transect route and recording every reptile seen, whether in the open or under a refuge. The study concluded that refuges are the most efficient way of finding smooth snakes, grass snakes and slow worms. Too few viviparous lizard and adders were found to enable a judgement to be made, while observation was more effective in the case of the sand lizard. At Lye Valley it was therefore expected that in the case of at least slow worm and grass snake, the use of refuges would be an effective way to survey (English Nature 1966).

From the six surveys undertaken, the total number of slow worms counted under mats was 107. For viviparous lizard 15 were recorded on top of mats, and one beneath a mat, making a total of 16. Only 2 grass snakes were recorded under mats, one large and the other a small young snake. The reptiles were found in certain very specific locations, with most of the survey mats producing negative results throughout the survey period. The distribution of reptiles in each of the habitats surveyed is given in table 3 below and the particular locations where they were found to be present are shown on figure 10.

Table 3. Numbers of reptiles found in each of the habitats surveyed (full habitat description given in table 1)

	Habitat type	Mat number	Reptile numbers
1	Grassland (10 mats)	56 – 60	Viviparous lizard – 7 in total, average of 1.16/survey
		76 – 80	None
2	Lightly shaded woodland/scrub (10 mats)	65 – 70	None
		71 – 75	None
3	Dense woodland/scrub, where there is ground vegetation (10 mats)	11 – 15	None
		16 – 20	None
4	Dense Reed (10 mats)	26 – 30	None
		31 – 35	None
5	Open reed/edge of open fen (15 mats)	21 – 25	Viviparous lizard – 1 in total, average of 0.16/survey Grass snake – 1 in total, average of 0.16/survey
		36 – 45	None
6	Edge of two habitats, grassland/bramble/line of trees (10 mats)	51 – 55	Viviparous lizard – 4 in total, average of 0.66/survey
		46 – 50	Slow worm – 21 in total, average of 3.5/survey
7	Tall herb (5 mats)	61 – 65	Viviparous lizard – 3 in total, average of 0.5/survey Grass snake – 1 in total, average of 0.16/survey
8	Allotments (10 mats)	1 – 10	Viviparous lizard – 1 in total, average of 0.16/survey Slow worm – 86 in total, average of 14.3/survey

Figure 10. Locations where reptiles were recorded

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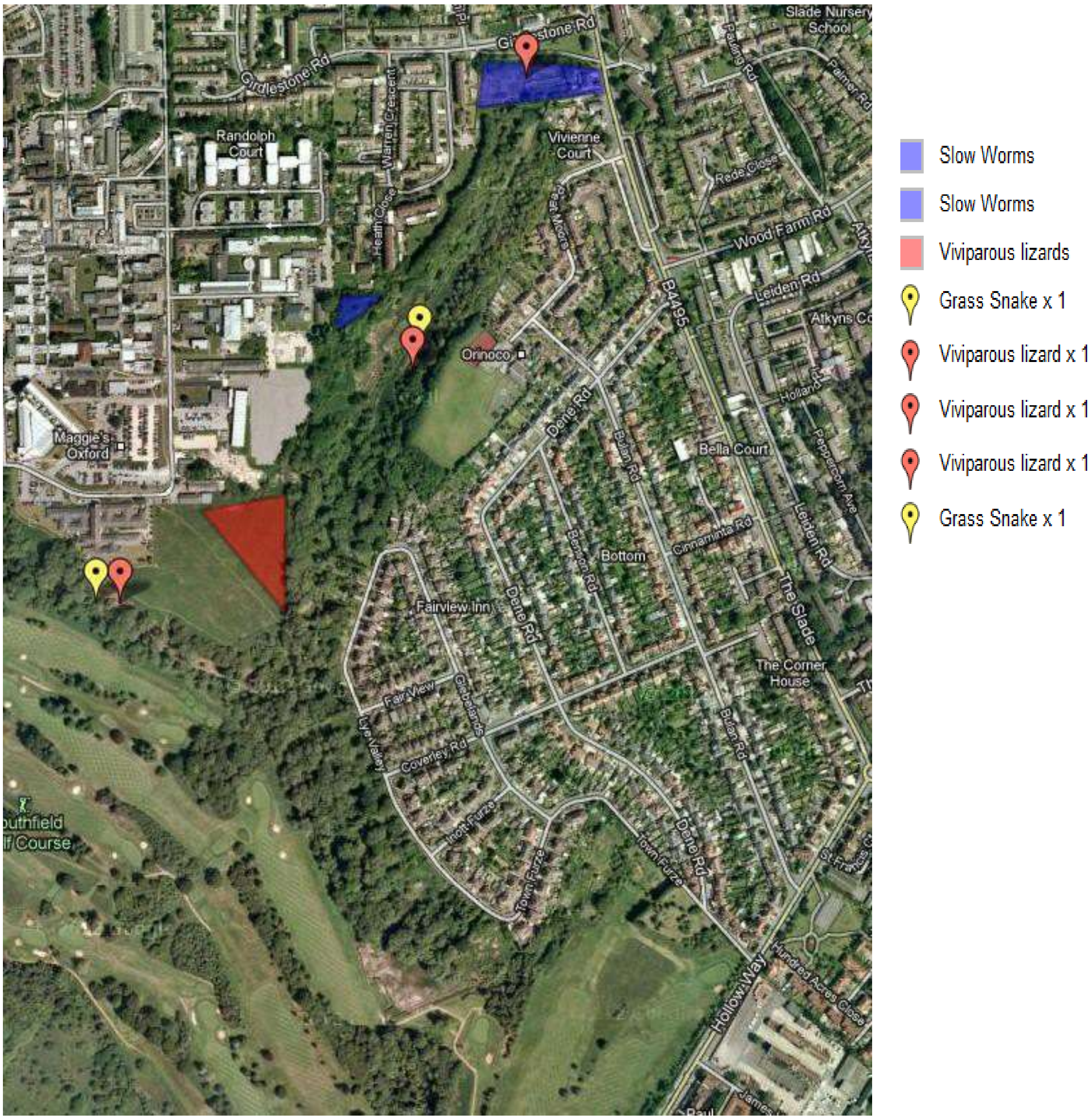


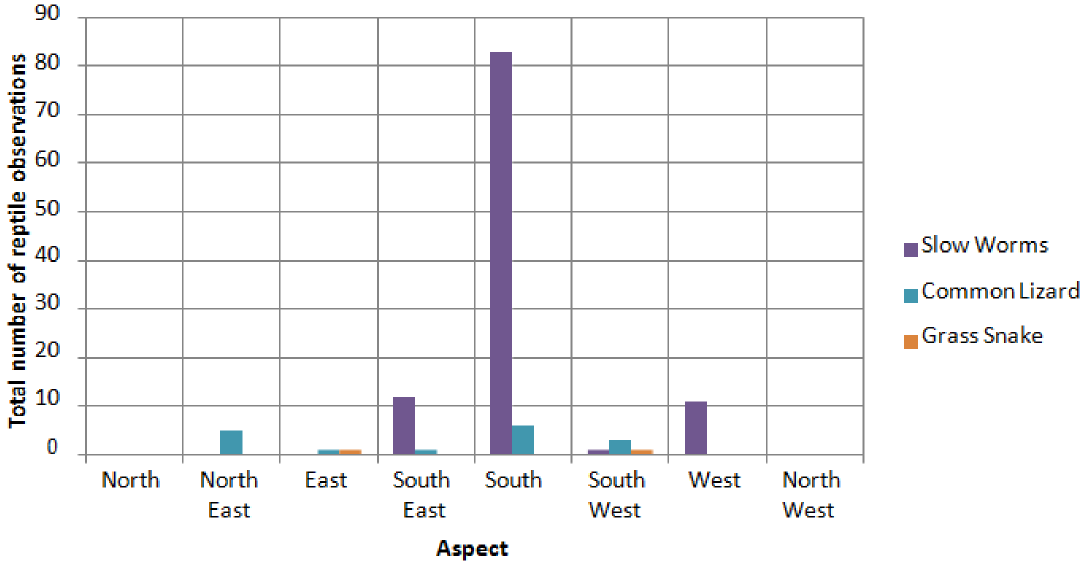
The habitats where no reptiles were recorded were the dense and open woodlands and the dense reed. No reptiles were recorded on the southern fen. This area had been selected as it was thought that it might provide good habitat for grass snake, especially the mounds of decaying cut fen vegetation around the edge of the fen. By far the most reptiles were recorded on the Town Furze allotments where 86 slow worm records were made and one of viviparous lizard. Other locations where reptiles were recorded included the edge of the northern fen (viviparous lizard and grass snake, once each); grassland south of Churchill Hospital (viviparous lizard, seven records). It is generally said that habitat interfaces provide good habitat for reptiles, due to the diversity of structure, microhabitats and microclimate (Edgar, Foster and Baker 2010). In this survey on edge habitats, 21 slow worms were recorded on the grassland south of Warren Crescent and four viviparous lizards on the northern boundary of the grassland south of the Churchill hospital where it adjoins an area of brambles/nettles.

Results

In relation to each of the variables assessed the results were as follows:

1. Aspect

Figure 11. The aspect of the mats and the number of reptile observations



Slow worms

There is a very strong correlation between aspect and slow worm observations. Over 80 of the slow worm observations were on mats which faced south. The remainder faced south east, south west or west. This is, however, at least in part, a result of the aspect of Lye valley, which faces south. Those slopes that were surveyed and face north west to north east include: the dense woodland (east), the open fen (north), dense reed (east) and the slope at Oxford golf course. Most of these provide unsuitable habitat for other reasons such as dense shade or saturated ground

Viviparous lizard

Five viviparous lizards were found on mats that face north east. However, all of these lizards were recorded on top of mat 59 which is located in open grassland. Although this particular mat had a north easterly aspect it only had a shallow angle of slope of 10° and was in a wide area of open grassland exposed to the sun. The other viviparous lizards were found on slopes that faced east; south east, south or south west.

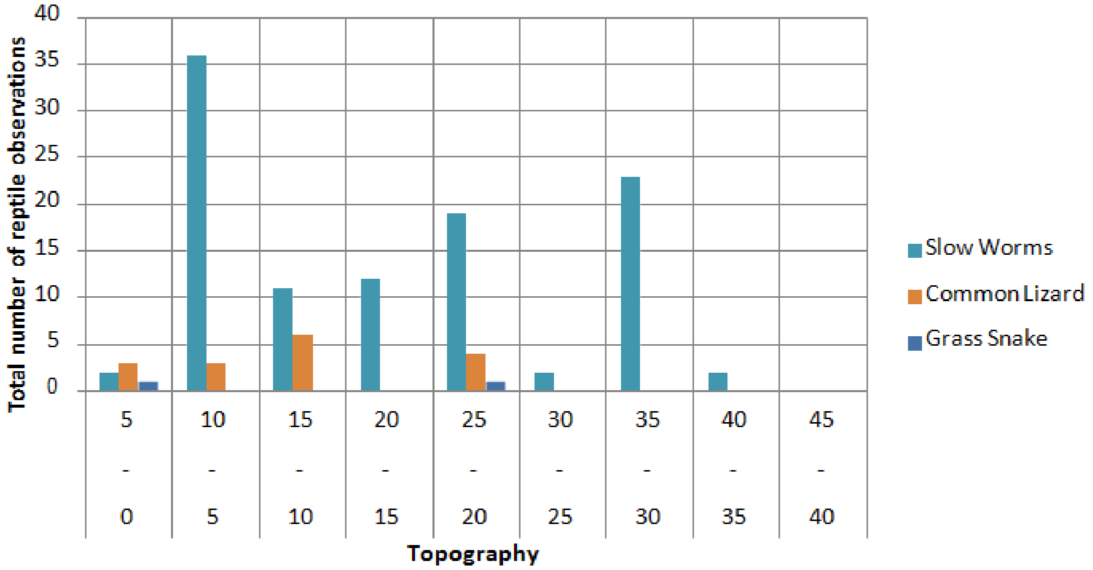
Grass snake

There were insufficient recordings to reach any conclusions.

2. Topography

Where there was a slope the angle varied from 5° to 40°C. While all viviparous lizards were found on slopes with an angle of between 0° and 25°C some slow worms were found under mats with an angle between 30° and 40°C. As all of the mats where slow worms were found also had an aspect of between south east and west there is considerable scope for accentuating solar radiation.

Figure 12. The angle of slope and the number of reptile observations



3. Weather conditions

Weather conditions are more likely to influence whether reptiles are observed during a particular survey. If weather is unsuitable it could result in no reptiles being recorded, although they are present on the site.

The weather during the survey period was cool and unsettled, see table 4. There were indications that weather conditions may have had some influence on reptile observations. In particular there were only two occasions when no viviparous lizards were recorded in the grassland south of the Churchill Hospital; on the first of these occasions the weather was windy. The grassland is rather exposed with no tall vegetation close by and reptiles are difficult to find when it is windy (Inns, 1996). Similarly on 14.7.12 the weather was cloudy with a cool breeze, with the temperature on the mats between 14 and 15°C, and the only viviparous lizard recorded was underneath survey mat 62 on the sheltered south facing slope south of the Fulbrook Centre. On this occasion the light levels in the grassland were also very low for this area with lux levels 4,490 - 5,490.

Table 4. Weather conditions during reptile survey at Lye Valley

Date of survey	Weather type
16 June 2012	Windy, dry, rather cloudy with a few sunny intervals
23 June 2012	Sunny periods am. More cloudy pm with a shower. When sun out, hazy due to thickening frontal cloud.
30 June 2012	Shower early, then sunny periods
7 July 2012	Mostly cloudy with heavy showers
11 July 2012	Sunny spells and heavy showers
14 July 2012	Cloudy, cool breeze and a little drizzle, becoming brighter and sunny from 15.30 – 17.00, before clouding over again.

4. Microclimate

Differences in microclimate between the different habitats on the site have been determined by calculating the average figures for ground and air temperature, relative humidity and light levels in each habitat; see table 5. However, the figures obtained must be treated with caution as it was not possible to take the readings simultaneously and so they vary according to the time of day and the weather. An attempt to overcome this was made by surveying the mats in a different order in the various surveys. However, the relative humidity readings were skewed by the multimetre giving a reading of 100%, during and for some time after a shower. The average readings of over 70% for several habitats in table 5, therefore reflect readings following showers.

Table 5. Differences in microclimate as indicated by the different average weather recordings over the surveys in the different habitats at Lye Valley

Location/habitat	Air temperature near ground (C)*	Ground temperature (C)**	Relative Humidity (%)	Light level (Lux)
Town Furze allotments	22.5	20.3	59.3	1008
Dense woodland (east)	20.9	19.3	60.0	433
Dense woodland (west)	21.6	19.0	59.7	181
Edge of open fen (north)	22.7	18.5	63.6	900
Dense reed (east)	22.6	17.9	59.3	1076
Dense reed (west)	21.8	18.4	61.5	969
Edge of open fen (south)	22.3	19.1	62.9	1046
Grassland near end of Warren Crescent	19.5	18.5	71.1	979
Grassland/bramble/nettle edge near Churchill Hospital	21.1	18.6	72.3	1236
Grassland south of Churchill Hospital	21.7	18.8	73.2	1696
South facing slope with tall vegetation south of Fulbrook Centre	22.5	19.5	64.3	1130
Open woodland near Lye Brook	20.6	18.2	67.6	579
Open woodland near Boundary Brook	20.4	18.0	70.2	694
North facing slope at Golf course	20.5	18.0	74.8	899

* Excludes 16.6.12 when temperature readings were taken 1 m above the mat

** Excludes surveys on 11.7.12 and 14.7.12 when no ground temperatures were recorded

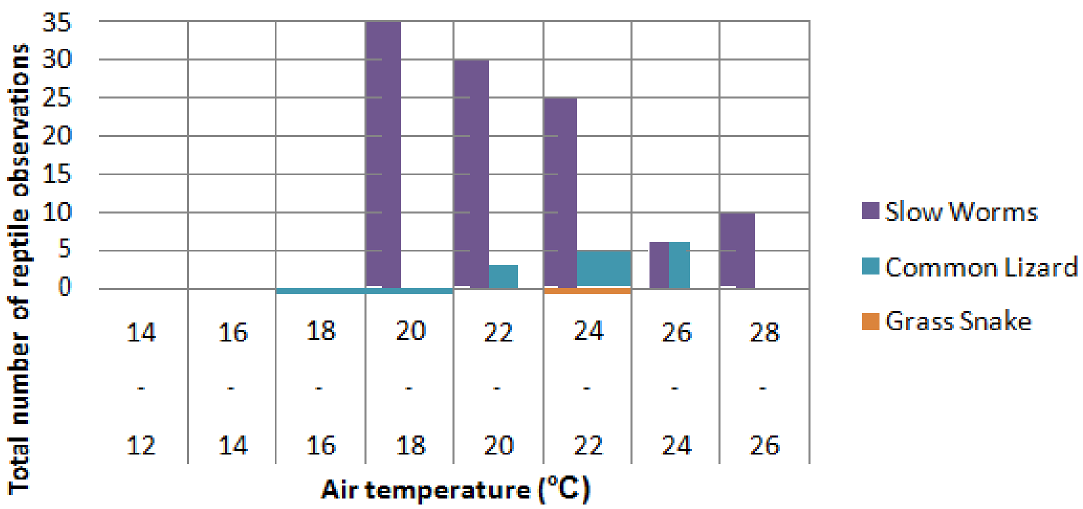
Average air temperature varied from 22.7^{o}C on the edge of the northern fen to 19.5^{o}C on the grassland near the end of Warren Crescent. High average readings of 22.5^{o}C were also recorded on the south facing slopes at Town Furze allotments and the slope south of the Fulbrook centre. In order to thermoregulate it would be expected that reptiles would be in those habitats where higher temperatures were recorded, and this was the case with grass snake, which was recorded at the northern fen and the south facing slope south of the Fulbrook Centre. The locations where most viviparous lizards were recorded were on the grassland south of the Churchill hospital and the grassland/bramble edge near the Churchill hospital; they had average recordings of 21.7^{o}C and 21.1^{o}C respectively, which were in the middle of the average recorded temperatures. In the case of slow worm the large population at Town Furze allotments was located where one of the highest average recordings of 22.5^{o}C was made, but the other smaller population at Warren Crescent was located where the lowest average reading of 19.5^{o}C was recorded.

Ground temperature varied from 20.3^{o}C on Town Furze allotments down to 17.9^{o}C on the dense reed east. This would be expected to be most strongly correlated with slow worms given that they spend much of their lives in the ground and rely on ground materials to thermoregulate. Again the allotments produced a high reading of

20.3°C, but the grassland at the end of Warren Crescent, where slow worms are also present, had the relatively low recording of 18.5^{o}C. It is in the area of light recordings that there is the most marked variation between habitats, with the four woodland areas recording much lower light than the more open habitats. The level was lowest in the dense woodland (west) where the average was a lux level of only 1,810. By contrast on the grassland south of the Churchill Hospital the average lux level was 16,960, and the grassland/bramble/nettle edge near the Churchill hospital had the next highest reading of 12,360, so at Lye Valley there is a positive correlation between light levels and viviparous lizard. This is not surprising as light levels reflect the degree to which solar radiation is being received and so are vital to basking and thermoregulation. The slow worms were not recorded in the areas of highest light levels, with the allotments having an average lux level of 10,080 and the grassland at the end of Warren Crescent 9,790. This is consistent with slow worms relying less on basking for thermoregulation. No reptiles were found in the woodland where low levels of light were recorded.

There was no clear relationship between reptiles recorded at Lye Valley and air temperature (figure 13). In the case of slow worms a significant number were recorded at temperatures between 18^{o}C and 28^{o}C.

Figure 13. Air temperature and the number of reptile observations

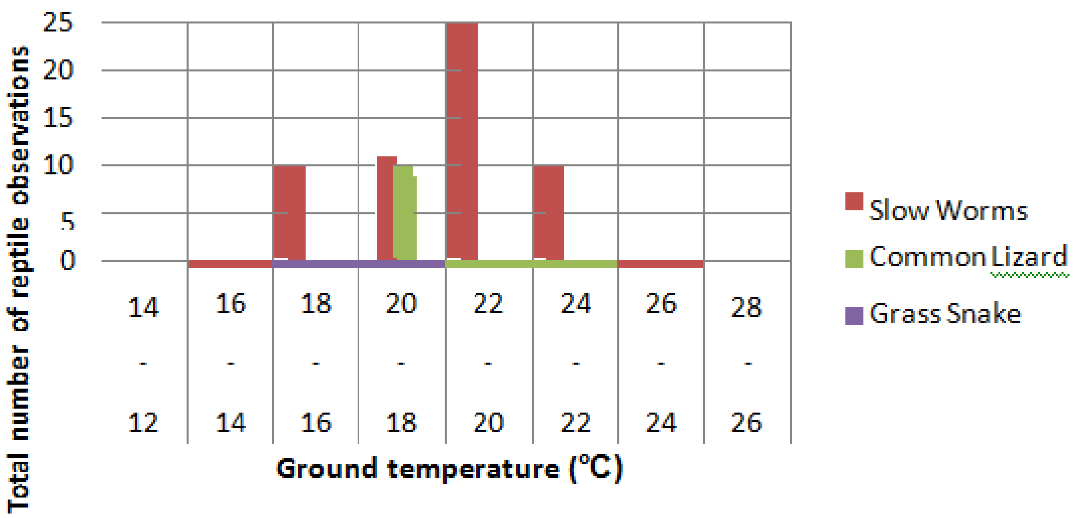


In the case of viviparous lizard the tendency was for more to be recorded at higher temperatures, though none were recorded at the highest temperatures of 26-28^{o}C. One was recorded at a low temperature of 16 -18^{o}C on 14.7.12, but notably this lizard was recorded beneath the mat, whereas all the others were on top of the mats. In the case of grass snake the only one recorded against air temperature was at 22- 24^{o}C, in relatively warm conditions.

The relationship was somewhat different in relation to ground temperature than air temperature. This is particularly noticeable in the relationship between ground temperature and average number of reptile observations.

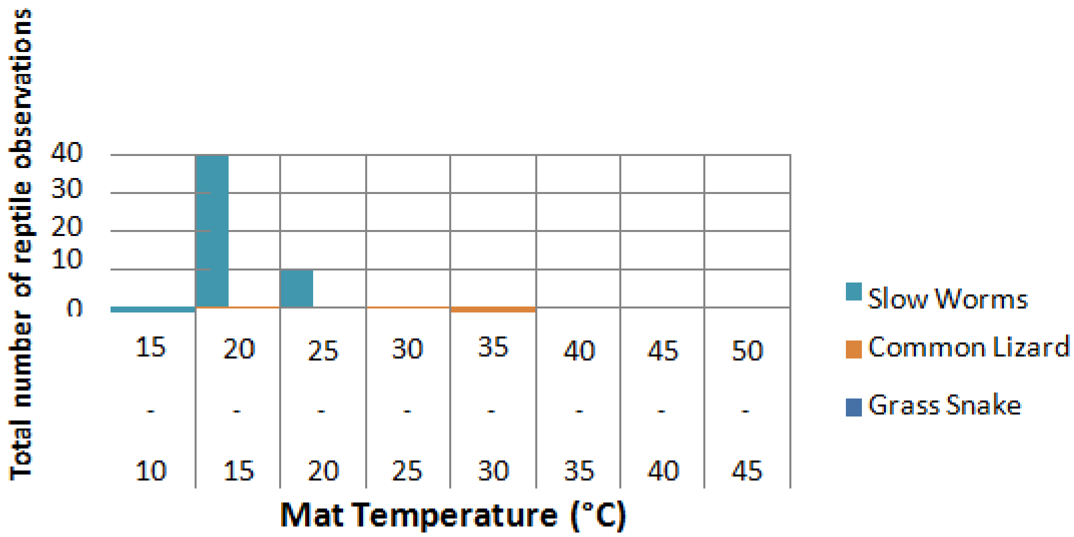
There were relatively few slow worm observations at lower ground temperatures, although there were some, but there was a peak between 22 and 24°C in warm conditions. In the case of both the viviparous lizard and grass snake there was no clear relationship between recordings and ground temperature, which is not surprising as these reptiles are normally above rather than below ground. (See figure 14)

Figure 14. Ground temperature and the number of reptile observations



Mat temperature was only recorded on 11.7.12 and 14.7.12. The data relates to the surface of the mats where viviparous lizards were usually recorded, not to the underside where the slow worms were found, although it would be expected that high mat surface temperatures, would be associated with relatively high figures on the underside. (See figure 15).

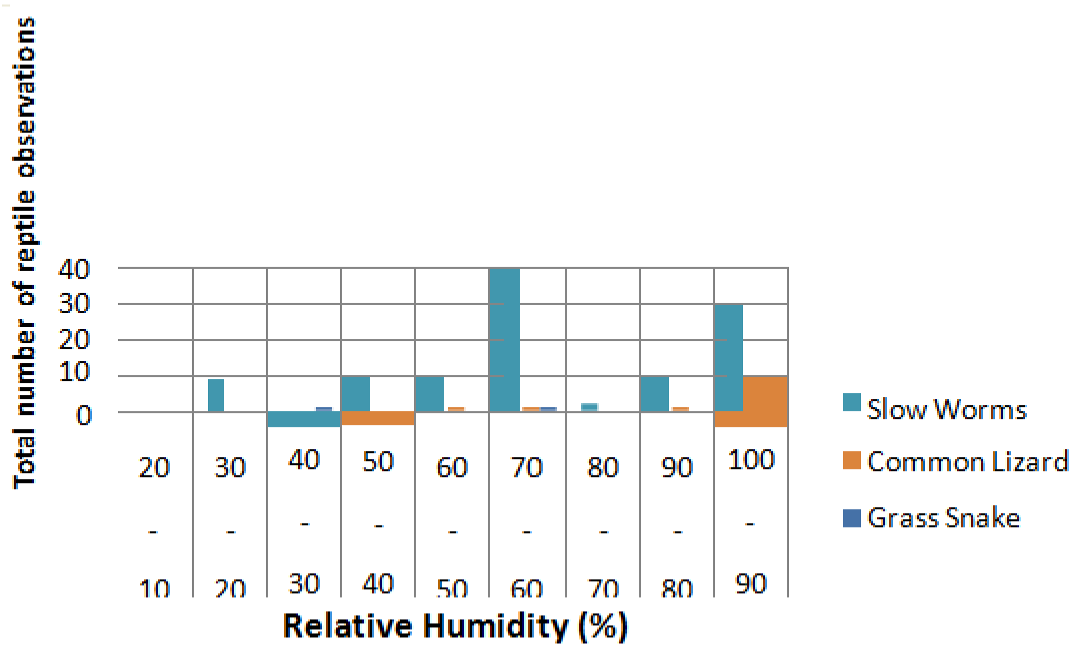
Figure 15. Mat temperature and the number of reptile observations



This indicates what would seem to be an interesting difference between reptiles, with all of the slow worms recorded at relatively low temperatures and all but one of the viviparous lizards at high temperatures. However, this could be misleading - the mat temperatures where the slow worms were recorded at the allotments and grassland near the end of Warren Crescent were relatively low on both of these survey occasions. However, the mat readings where the viviparous lizards were recorded were very high on 11.7.12, it being bright sunshine in mid-afternoon. They were much lower when the next readings were taken mid-morning on 14.7.12, but on this occasion only one viviparous lizard was recorded beneath a mat. If mat temperature had been recorded throughout the survey a more complex relationship might have been found.

This survey did not indicate any clear relationship between humidity and reptile records (See figure 16).

Figure 16. Relative Humidity and the number of reptile observations



5. Vegetation height

It was not possible to give a representative figure indicating vegetation height as many of the mats were located at the boundary between two vegetation types or forms of management. For example, at Town Furze allotments the vegetation was frequently over a metre tall behind the mats, but only a few centimetres tall at the other side where the mat fronted a path, while the other two sides had vegetation in between these heights. The same problems occurred at other sites such as the edge of the northern fen and the grassland/ bramble/nettle edge near the Churchill hospital, while in the woodland areas there were two layers of vegetation height and no means of accurately measuring the tree height. No statistical analysis of this factor has therefore been possible. However, no reptiles were recorded in the woodland areas or the dense reedbeds, which indicates that vegetation height is likely to be an important factor. Slow worms were, however, found under mats 7 and 8 at the allotments, which were under the canopy of a hawthorn bush and dog rose respectively and at the grassland near the end of Warren Crescent they were found under mats 46 and 47 close to a line of field maple and hawthorn and under mat 50 close to a hawthorn bush. However, in each of these cases, the trees were to the north, or in the case of mat 50, where the bush was to the south east there was extensive opportunity for solar radiation from midday onwards. Some of the other survey mats were also located right on the edge and partially within tall vegetation, as at Town Furze allotments. However, it is noticeable that under mat 10 which was totally overshadowed by willow herb, convolvulus and bramble to the south no slow worms were recorded. This was the most overshadowed mat in the allotments and the only one which did not yield any slow worm.

The viviparous lizard records on the grassland south of the Churchill Hospital were in one of the shorter areas of vegetation, mostly 10 - 40 cm. However, the dense nature of the uncut grassland and its varying height provides shelter from predators. In the case of the grassland/bramble/nettle edge near the Churchill hospital, mat 2 on the allotments and mat 62 on the slope south of the Fulbrook Centre, where viviparous lizard were also recorded, contained taller elements of vegetation.

It would seem that reptiles are not fussy about vegetation height provided the food, shelter and solar radiation necessary can be obtained. This probably makes both tall vegetation, such as dense reedbeds, and very short vegetation unsuitable and makes medium height vegetation with plenty of structure the preferred location.

6. Vegetation type

No reptiles were recorded in the four woodland areas, the reedbeds or the southern fen.

Viviparous lizard

This was found in a variety of vegetation types. Grassland produced the most records with seven on the area south of the Churchill hospital. However, other grassland areas did not produce any observations. The second most productive area was the grassland/bramble/nettle edge near the Churchill hospital, where 4 were recorded. This forms the boundary between the grassland where the other 7 were recorded and an area of dense bramble/nettles, which is much more shaded, but might provide cover for lizards from predators. On three separate occasions a lizard was found at mat 62 on the south facing slope near the Fulbrook Centre. This may have been the same individual as no other viviparous lizards were recorded in this location. This mat was located in an area dominated by grass, but surrounded by nettles, bramble, and convolvulus. One lizard was also recorded at the allotments on mat 2, where the surrounding vegetation consists of nettles, brambles, convolvulus and long grass and one at the northern fen on mat 25, at the boundary of an area of dense hemp agrimony and reed on its eastern side and thistles, reed, cleavers, meadowsweet, and rush to the west. While grass, therefore, often formed a component of the vegetation where the viviparous lizards were found, other vegetation types were also often present.

Slow worms

These were found in grassland at Warren Crescent in an area of grassland between a row of field maple and hawthorn and an area of dense brambles and nettles. At Town Furze allotments all of the mats but one were located around the edge of the allotments where the ground vegetation is dominated by nettles, bramble, long grass, thistles, and cleavers. However, mat 6 was away from the site boundary in an area of grass that is regularly cut. This mat was as productive of slow worms as those round the site boundary.

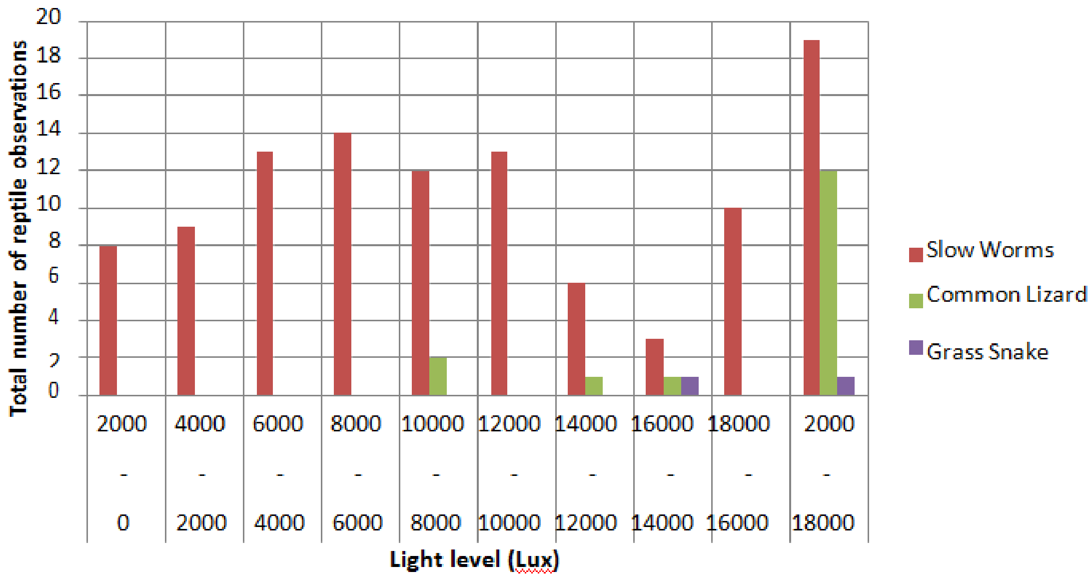
Grass snake

One was on the south facing slope with tall vegetation south of the Fulbrook centre where the vegetation was dominated by grass, nettles, Himalayan Balsam and scattered reed. The other was on the northern fen where the mat was at the boundary between tall dense and more open vegetation.

7. Light

Figure 17 indicates that slow worms were recorded over a wide range of light levels, with significant numbers even when light levels were low.

Figure 17. Light level and the number of reptile observations

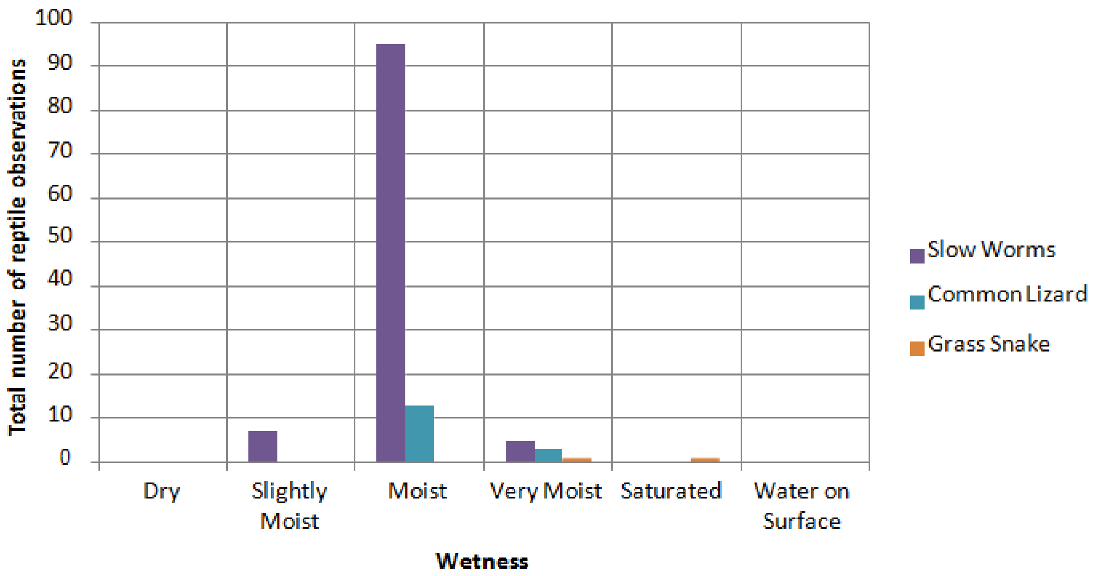


For example, 22 slow worms were recorded in late afternoon on 14.7.12 despite low light levels, with six being found under one mat with a lux level of only 1,990. This may be because the mats still retained some warmth from a period of sunshine earlier in the afternoon. However, on the same day three slow worms were recorded in low light levels at Warren Crescent between 8.20 and 8.40 in the morning. By contrast for viviparous lizard most of the recordings were at high light levels. There were only two exceptions: one was the lizard found underneath mat 62 on 14.7.12 with a lux level of 9,090, which was the only lizard found underneath a mat. The other was recorded on mat 53 on the grassland south of the Churchill hospital on 23.6.12 at a lux level of 8,700. A few minutes earlier two lizards had been recorded at the maximum light level on the multimetre on mats 51 and 52, and it is therefore likely that the lizard on mat 53 was basking in sunshine when the sun went behind a cloud just before the observation was made. There was a strong positive correlation between light levels and records of viviparous lizard

9. Ground conditions and reptile observations

The relationship between ground moisture and reptile observations is given in figure 18.

Figure 18. Ground Moisture and the number of reptile observations



Due to the unsettled weather, ground conditions were consistently moist during the summer of 2012. The soil under only two mats was ever recorded as dry, these being mats 5 and 8 at Town Furze allotments on 30.6.12. No reptiles were found under or over them on this occasion. Most of the reptiles were found under or over mats where the soil was moist. This applied to 95 out of the 107 slow worms recorded. The remaining 12 slow worms were found under conditions recorded as slightly or very moist. None were recorded where the ground was saturated or with water on the surface. Most viviparous lizards were also found where the conditions were moist. However, the lizard recorded at the northern fen was on top of a mat where the ground conditions were recorded as 'very moist,' (Mat 25) on 16.6.12. Similarly, the ground conditions underneath mat 59 where two lizards were recorded on 7.7.12 were very moist following a shower. One of the two grass snakes recorded was also found under a mat at the northern fen with the ground conditions recorded as saturated. (Mat 22 on 16.6.12), with the only other grass snake being recorded under mat 61 on 7.7.12, in conditions which were very moist. The most marked feature of the survey was the paucity of reptiles where the ground conditions were saturated. Ground conditions were saturated for most of the records relating to the northern and southern fen and the eastern and western dense reeds, yet only one grass snake was recorded where the ground conditions were recorded in this category.

Discussion

This survey indicated that in most cases there was some correlation between the location where the reptiles were found and the environmental variables assessed. The indications are that each of these factors is contributing and many of them are interlinked, such as topography, aspect, and microclimate. However, the association was not generally strong.

Topography/aspect

The standard texts such as Beebee and Griffiths (2000) and Edgar, Foster and Baker (2010) state that south facing slopes are particularly favoured by reptiles. This is corroborated by studies such as the slow worm study of Worcester (in Shepherd, 1997), which found that the slow worms stronghold was on the west and south west facing slopes of the hilly area on the eastern edge of the city (Shepherd, 1997). Similarly, Pollard, Hooper and Moore (1979) noted that the viviparous lizard is common on the hedge banks of the Wealden sands, but is relatively rare in the clay areas of the Midlands where banked hedges are rare.

The reason for this is that topography/aspect has a profound impact on the amount of solar radiation received. An inclined surface that faces south receives significantly more solar radiation and heat than a flat surface. For example in Germany a surface inclined at 20° facing towards the south receives roughly twice as much radiation in January as a horizontal surface (Geiger, 1975).

Weather conditions

Gaywood and Spellerberg (1995), state that ‘Any survey procedure which aims to provide data which can be comparable must have certain standardised protocols. In the case of reptile surveying, it is the thermal environmental conditions which are a critical element in any standardisation.’ Some research has already been carried out on reptiles and temperature. Riddell found that slow worms were active between 8 – 22^{o}C, but 11 - 17^{o}C was preferred. Viviparous lizards were generally active at slightly higher temperatures, 11 – 24^{o}C with very few active below 10^{o}C (Riddell, 1996). According to Cheung and Gent (1996), the optimum temperature for detecting reptiles using refugia was 15 – 18^{o}C at a site at Fineshade Woods in Northamptonshire and 23^{o}C at Frimley Hatches in Hampshire. They conclude that the best temperatures for survey work are between 15 and 25^{o}C, with less cloud at the lower end of the scale and more cloud at the higher end of the scale. Inns (1996) claimed that the ideal conditions for reptile survey work were 11 - 19^{o}C with sun or hazy sunshine and little or no wind. On the days of the Lye Valley surveys there were no excessively high or cool temperatures, which is likely to have provided very good conditions

However, Gleed-Owen et al. (2005) state that ‘None of these studies measured relative humidity, although this is likely to have a significant (positive) effect on reptile activity. The ‘inexplicably poor’ results of some apparently suitable survey days, and the surprisingly high results of other days, may be due to this unmeasured factor.’ In the case of the Lye Valley survey humidity was recorded, but no relationship with reptile findings was detected.

Microclimate

Given that Britain’s reptiles spend most of their time close to the ground or within the ground, it is important to recognise that the climate at ground surface level can be significantly different to air temperatures recorded in a Stevenson screen one metre above ground level. Because the ground surface absorbs and emits radiation, evaporates and condenses water, and restricts air movement, it greatly affects the conditions in the air close to the ground. In particular the temperature of the ground responds more quickly to changes in weather than air temperature. This results in often extremely high temperatures in the day and much colder ones at night. In cool damp climates humidity is also often markedly higher at a height of 5 cm than 1 m, while there is a marked reduction in wind speeds (Geiger, 1975).

The temperature near the surface is also profoundly affected by vegetation cover. This is because the leaves and branches absorb and emit radiation. When the vegetation is thick the ground surface entirely loses its function as a boundary surface with the atmosphere, which is replaced by the upper surface of the vegetation. Due to the vegetation structure there is a vertical distribution to the radiation received and emitted by vegetation which means that temperatures are lower by day and higher by night than for bare ground. Wind strength is also much less. A third difference is in relation to humidity. Plants absorb large amounts of water through their roots and then return it to the atmosphere through their leaves, so that relative humidity is high. Rather than the large scale turbulence and temperature fluctuations of bare ground ‘a quiet, moist, protective climate prevails’ (Geiger, 1975).

Long grass can also significantly affect the temperature in spring when reptiles are waking from hibernation. Norman, Kemp and Taylor found during 1953 - 54 at two meadows near the Thames only 5 m apart, in one of which the grass was only 2 -3 cm tall, while in the other it was 30 -45 cm tall, that at 2.5 cm above the ground the maximum temperature was 4.6^{o}C lower in the tall grass during the period 24th February – 23rd March. Given that this is when reptiles are emerging from hibernation, such a difference is significant (Geiger, 1975). Vegetation has a major impact on the temperature near the ground and must therefore significantly impact on reptiles as they seek to thermoregulate, both for them to be able to bask and also the need for shade to avoid hot conditions. Such microclimate conditions may also enable a reptile that is near the edge of its range to survive in certain particularly suitable microclimates.

Vegetation height/type

Viviparous lizard at Lye Valley was particularly associated with grassland. This has also been found in other studies. For example, Riddell (1996), who surveyed an area of woodland; a flower meadow and an area of rough grassland at Canterbury Environmental Record Centre in 1995 recorded 45 viviparous lizard in the rough grassland but very few in the other two habitats.

However, Ratcliffe (2002) states that on the Cumbrian fells, the viviparous lizard “is common and frequent on all of the more heathery fells, but is less common where grassland prevails, perhaps because of the lesser shelter.” Beebee and Griffiths (2000), state that it needs undisturbed ground that is topographically diverse with fairly dense but short vegetation less than 0.5 m high, open to the sun with at least a few exposed areas or promontories that can be used for basking. The undisturbed grassland south of the Churchill Hospital would appear to provide ideal habitat for it. For the slow worm, Riddell (1996) found the largest number in the rough grassland, but there were also some in the flower meadow and the woodland area. Beebee and Griffiths (2000), note that they occur in a variety of habitats including “rough grassland, hedgerows, heathland, woodland edges, downs and moorland. They regularly frequent habitats influenced by man, and railway and motorway embankments as well as gardens, churchyards, parks and allotments are all utilised." Their use of allotments is a well-established characteristic that was found also in Worcester (Shepherd, 1997)**.**

Light levels

The need for reptiles to bask is well established so it is not surprising that a positive association with light levels was established.

Ground conditions

These are most likely to be important for slow worms which spend much of their time in the ground hunting for molluscs and worms. Marshy and very dry ground is usually avoided (Beebee and Griffiths, 2000). In Worcester it was found that there were no slow worms in the floodplain of the River Severn, which was attributed to winter flooding preventing hibernation (Shepherd, 1997).

However, the strongest evidence for the importance of ground conditions to slow worms was found by Riddell (1996), at Canterbury Environmental Education centre during the extremely hot summer of 1995, when average temperatures were 5^oC above normal and no significant rain fell between 14th June and 2nd September, which resulted in no slow worms at all being recorded for a six week period. After the drought broke from 2nd September to 19th October only 14 slow worms were recorded and these were in extremely poor condition. She considered this impact might have been associated with the drying out of artificial compressed clay bunds where they were found. Clearly the very wet summer of 2012 provided good ground conditions for them at Lye Valley.

Food supply

Incidental records were kept on a number of the surveys of invertebrates found underneath the mats. In many parts, including the dense woodland there was a plentiful supply of various types of invertebrates including molluscs, though curiously slugs seemed to be largely absent from the southern fen. The Lye Valley also contains three ponds with frog tadpoles and adults in 2005, but no newts (D'Ayala and Townsend, 2005). There are also plentiful small mammals, which are sometimes taken by grass snake. Food therefore is probably not a constraining factor.

Conservation

In order to determine the conservation significance of Lye Valley for reptiles it is necessary to ascertain the significance of the survey observations. Using Froglife's guidelines (Appendix A) the slow worm population would be classified as medium. The viviparous lizard would be on the margin of small /medium, while the grass snake population would be small. However, these guidelines recommend the use of at least 100 refuges/ha. In this case 80 refuges were used in an area of about 4.0 ha. If a greater density of refuges had been used, particularly in key areas of habitat it is likely that this would have confirmed at least a moderate population of viviparous lizards.

It is not possible from the data obtained to provide an estimate of the total reptile population found at Lye Valley. The Natural England Guidelines (Appendix B) indicate that the only way to do this is by capture-mark-recapture. Alternatively exhaustive surveys with over 20 visits per season with a high density of sampling points may also help to provide a population estimate.

Lye Valley does provide a large area of semi-natural habitat and in an urban context is of significance. It would seem from the surveys that the slow worm population is confined within two relatively small areas.

However, there have been a number of surveys elsewhere in the Lye Valley and Boundary Brook corridors, and these yielded hardly any reptile records; one viviparous lizard at Lye Valley fen and one grass snake seen at a pond near Boundary Brook, between the Churchill hospital and Warneford Meadow. (See figure 19). It would seem from these records that reptiles are not widely distributed in the Lye Valley area, which increases the conservation significance of those found.

Figure 19. Areas surveyed for reptiles in the Lye Valley

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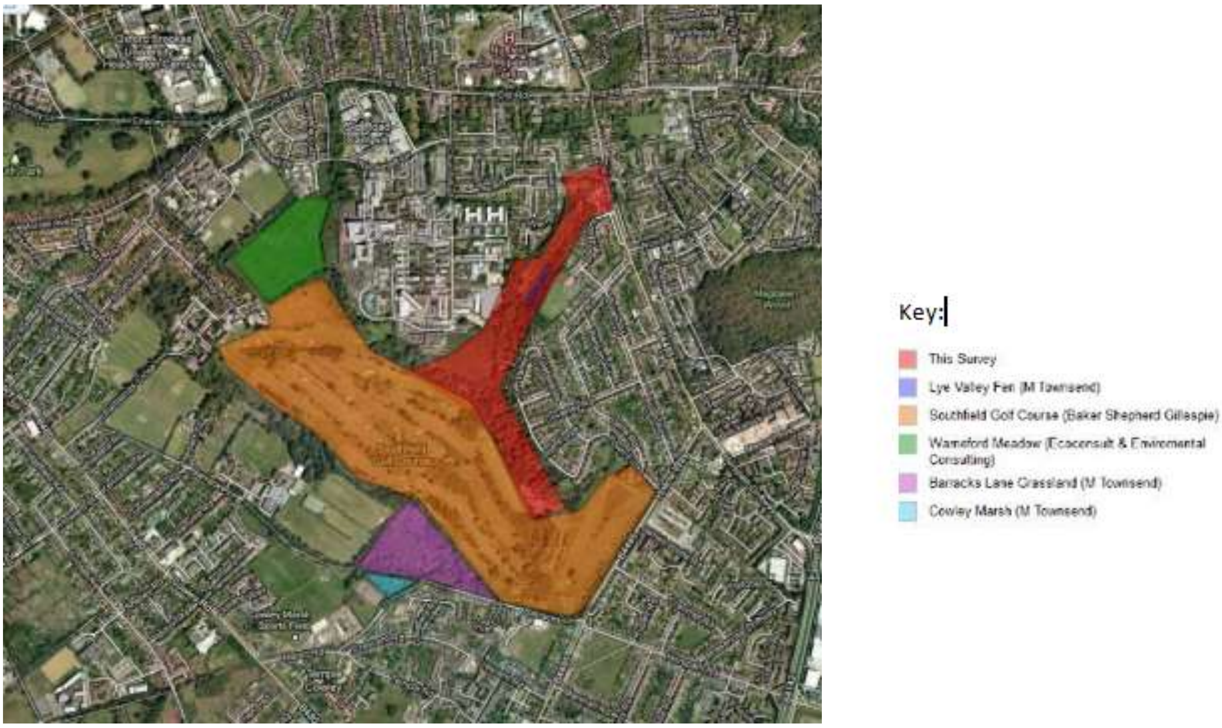

There is a large area of semi-natural habitat in the Lye Valley, but it is wholly surrounded by urban areas and roads. It is likely that the slow worm and viviparous lizard will have been there since before the surrounding housing estates were erected and that if they became extinct there may not be the opportunity to recolonise. Surveys in other parts of Oxford have indicated that on many potentially suitable sites there are no reptiles (D'Ayala and Townsend, 2005). In a city- wide context therefore the reptiles found at Lye Valley have major conservation significance.

To promote their conservation it would be profitable to determine the extent of viviparous lizard occupation of the area, including whether it is widespread over the whole of the grassland south of the Churchill Hospital. The slow worm is clearly doing very well at Town Furze allotments, owing to sympathetic management and enthusiasm from the allotment holders. It is important that this is transmitted to future tenants. There seems to be only a small population in the grassland at the end of Warren Crescent, which could be under threat from advancing brambles and nettles. Appropriate management of this area could enable this population to survive and expand.

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Appendix A

Survey Assessment of Key Reptile Sites - from Froglife

The Key Reptile Site Register is a mechanism designed to promote the safeguard of important reptile sites. The criteria for site selection are given below, including table 6 which allows the classification of the relative size of reptile populations on the basis of survey counts. Compare your survey results with the criteria given below to obtain an objective evaluation of the importance of the reptile interest on your site.

To qualify for the Key Reptile Site Register, the site in question must meet at least one of the following criteria:

1. Supports three or more reptile species
2. Supports two snake species
3. Supports an exceptional population of one species (see table 6)
4. Supports an assemblage of species scoring at least 4 (see table 6)

Does not satisfy 1 – 4 but is of particular regional importance due to local rarity, e.g. in the East Midlands of England, adders are very rare so even "low" populations should be designated as Key Sites.

Table 6.

	Low population Score 1	Good population Score 2	Exceptional population Score 3
Adder	<5	5 - 10	> 10
Grass snake	<5	5 - 10	> 10
Viviparous lizard	<5	5 - 20	> 20
Slow worm	<5	5 - 20	> 20

Figures in the table refer to maximum number of adults seen by observation and / or under tins, placed at a density of up to 10 per hectare, by one person in one day.

Appendix B

Deriving a population size class category using survey counts or habitat suitability assessment (Natural England 2011)

Table 7. Population size class

Species	Small	Medium	Large
Slow worm	< 10, or presence and "poor" habitat suitability	10 – 40, or presence and "good quality" habitat suitability	>40, or presence and "exceptional" habitat suitability
Viviparous Lizard	< 5, or presence and "poor" habitat suitability	5 -20, or presence and "good" habitat suitability	>20, or presence and "exceptional" habitat suitability
Grass Snake	< 5, or presence and "poor" habitat suitability	5 -10, or presence and "good" habitat suitability	>10, or presence and "exceptional" habitat suitability

The guidelines for using these two techniques are as follows:

Method a: Peak count

For each species, the first figure is the peak count of adults obtained by a thorough survey (by whatever method) under good conditions in one day, and at the optimal time of year for the target species. These figures can be derived from your presence/absence survey or from another recent survey done to a sound standard. For all three species June is one of the months classified as optimal.

Method b: habitat suitability assessment:

Establish the presence of the species and then assign a population size class estimate on the basis of a "habitat suitability assessment".