Validation of reptile survey methodologies

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Introduction

In the past, artificial refuges, usually in the form of pieces of corrugated sheet steel, have been extensively used as a tool to survey for the presence of reptiles at a given site. This has usually been done using a variable, but often small, number of refuges laid out either randomly or where reptiles are expected to be found and often over rather short periods of time and within relatively small patches of larger areas of possible reptile habitat. Similarly, random walks or transect walks have been done by both 'experienced' and 'inexperienced' observers searching for reptiles at sites of interest. As with the use of refuges, these walks have tended to be done in an unstructured manner with respect, particularly, to the length of the walk, the time spent searching and the expertise of the observer.

The reptile captures/sightings resulting from the use of refuges or 'walks' in the ways described are of limited value as they can only reveal the presence of reptiles if animals are actually seen but not absence if animals are not seen. Information that cannot be gained using these methods is that relating to the number of reptiles at a particular site or that enabling comparisons to be made between sites, particularly when the methods used are not even standardised between them. Unfortunately these methods have, all too frequently, been used to make just such statements by those who have a particular viewpoint regarding the threat to and/or conservation of reptiles at specific sites.

If herpetologists wish to make statements about reptile numbers at particular sites or make comparisons between sites then there needs to be a standardisation of the methods used. To this end English Nature (EN) funded ITE to compare the two methods commonly used (refuges and walks) and determine, if possible, a standard method for the surveying of reptiles. The preliminary results presented here will form part of a more comprehensive report to EN and will therefore only deal with some aspects of using refuges (not walks) to survey for reptiles.

Methods

During the field seasons of 1993-95 the reptile (and amphibian) species present at a heathland site in southern England were surveyed using hexagonal 'arrays' of artificial refuges (Figure 1) whose ground density varied both between arrays and years. Refuges were pieces of galvanised corrugated sheet steel measuring approximately 76cm x 65cm (2ft-6in x 2ft-1in) and painted black ('Hammerite') on the upper surface to aid heat absorption. Refuges within an array were placed in a hexagonal pattern so that each could be regarded as being at the centre of a circle (radius = half the distance between adjacent refuges) that only minimally overlapped with circles associated with adjacent refuges. In addition, refuges could be removed from, or added to, existing arrays to maintain the overall hexagonal pattern, thus varying the density of refuges used over what was essentially the same area of heath (eg Figure 1). Three different arrays were used each year, each being duplicated so that six areas of heath were covered in refuges. The number of refuges used in individual arrays during the three year study ranged between 7 and 127 with inter-refuge distances (IRD) of 5.8m - 30m and individual array areas of 0.335-0.597 hectares. The total area covered by refuge 'arrays' in each of the three years (1993,94,95) of the study were 2.862, 2.536 and 2.274 hectares respectively.

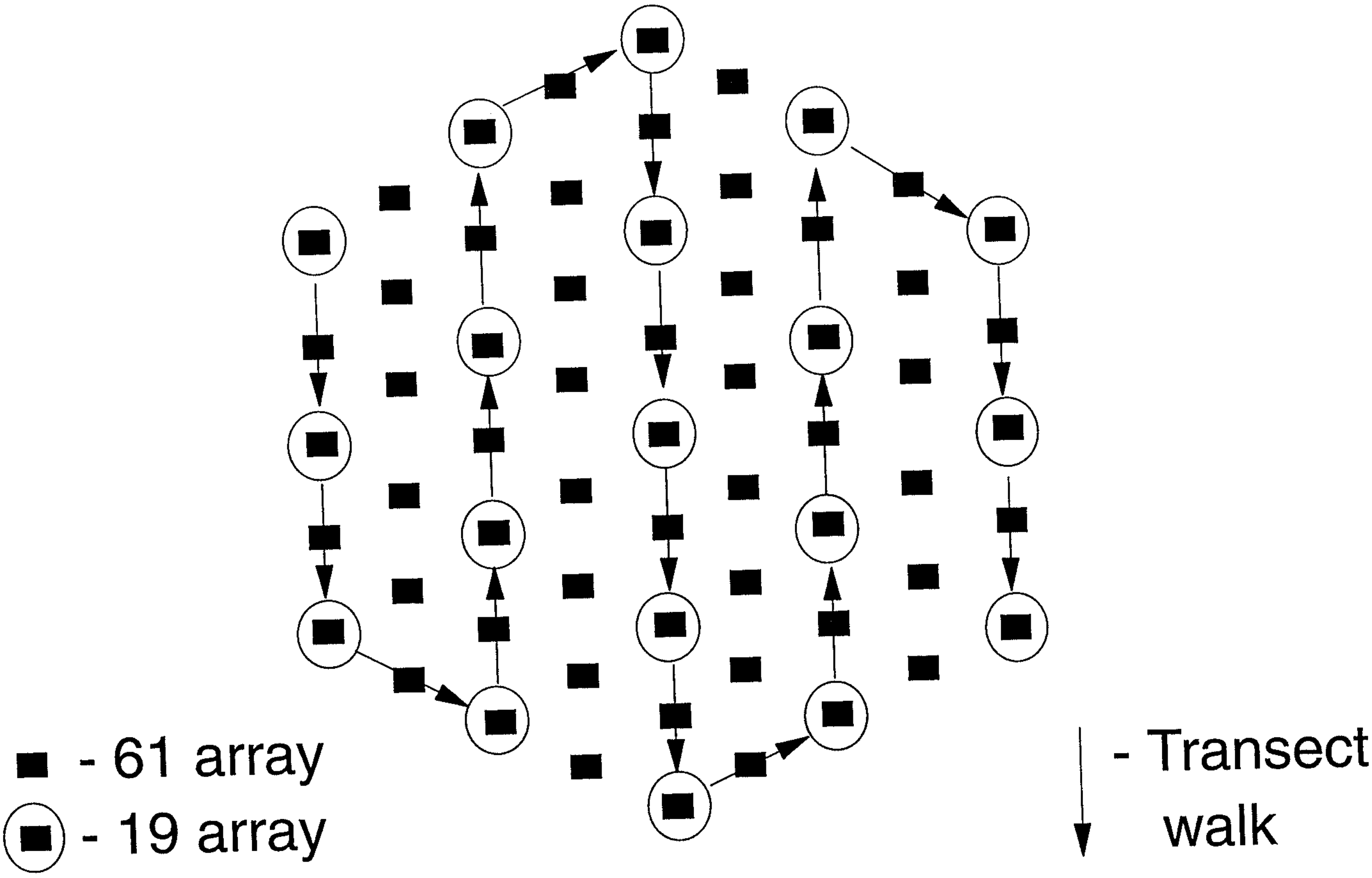

Figure 1. Example of a refuge array layout

Refuges within each array were checked either 25 or 28 times each year, between March and October, by walking a set route between refuges (transect walk) during which reptiles were also searched for by eye. A total of 174 refuges were used in 1993; 330 in 1994 and 270 in 1995. The data and position of every reptile sighting was recorded and every snake was captured, weighed, measured (snout/vent length and tail length), sexed and previously unmarked animals individually marked by inserting a PIT (Passive Integrated Transponder) tag under the skin on the side of the snake 2-5 cm anterior of the cloaca).

Results

The most frequently caught/observed reptile species in each of the three years (in diminishing order) were smooth snakes *Coronella austriaca*, slow-worm *Anguis fragilis*, sand lizard *Lacerta agilis* and grass snake *Natrix natrix*. Adders *Vipera berus* were found only during 1993 and 1994 and a single common lizard *Lacerta vivipara* were seen in 1994. Two amphibian species (common toad *Bufo bufo* and palmate newt *Triturus helveticus*) were also occasionally found within the study area (Table 1).

Table 1: Number of reptile and amphibian captures each year.

Species	1993	1994	1995
Smooth snake *Coronella austriaca*	134	130	57
Grass snake *Natrix natrix*	16	25	3
Adder *Vipera berus*	2	4	0
Sand lizard Lacerta agilis	45	29	22
Slow-worm *Anguis fragilis*	134	103	39
Common lizard *Lacerta vivipara*	0	1	0
Common toad *Bufo bufo*	19	0	0
Palmate newt *Triturus helveticus*	0	1	1

The three lizard species were not PIT tagged because they were either too small (common lizard), observed but rarely captured (sand lizard) or their body structure prevented the use of PIT tags (slow-worm). The number of individuals contributing to the overall number of captures for each snake species are shown in Table 2. The apparent decline in the numbers of individuals of all species captured in 1995 compared with the previous two years is almost certainly an anomaly resulting from the very hot dry summer of 1995 during which reptiles were avoiding the sun (basking) or additional warmth (refuges) rather than seeking it in order to raise their body temperature.

Table 2: Number of individuals captured each year.

Species	1993	1994	1995
Smooth snake *Coronella austriaca*	44	47	30
Grass snake *Natrix natrix*	9	12	3
Adder *Vipera berus*	2	3	0

The following preliminary results refer **only** to the smooth snake as this was by far the most abundant and frequently caught snake species within the study area.

Smooth snake

Although the refuges were checked throughout the spring and summer (March-October), when climatic conditions indicated that reptiles might be found, the highest proportion of captures occurred during May (23-32%), June (29-37%) and September (16-26%) with 54% and 61% occurring during May+June in 1994 and 1995 respectively. Although no site visits were able to be made in May 1993 it is very likely that a similar pattern of captures to 1994/95 would have been found (Figure 2). During the summer months the lowest proportion of captures occurred during July (1993-95 : 7-11%) and August (1993-95 : 0-21%) whilst very few were found in March/April or October (except 1995 : 12%).

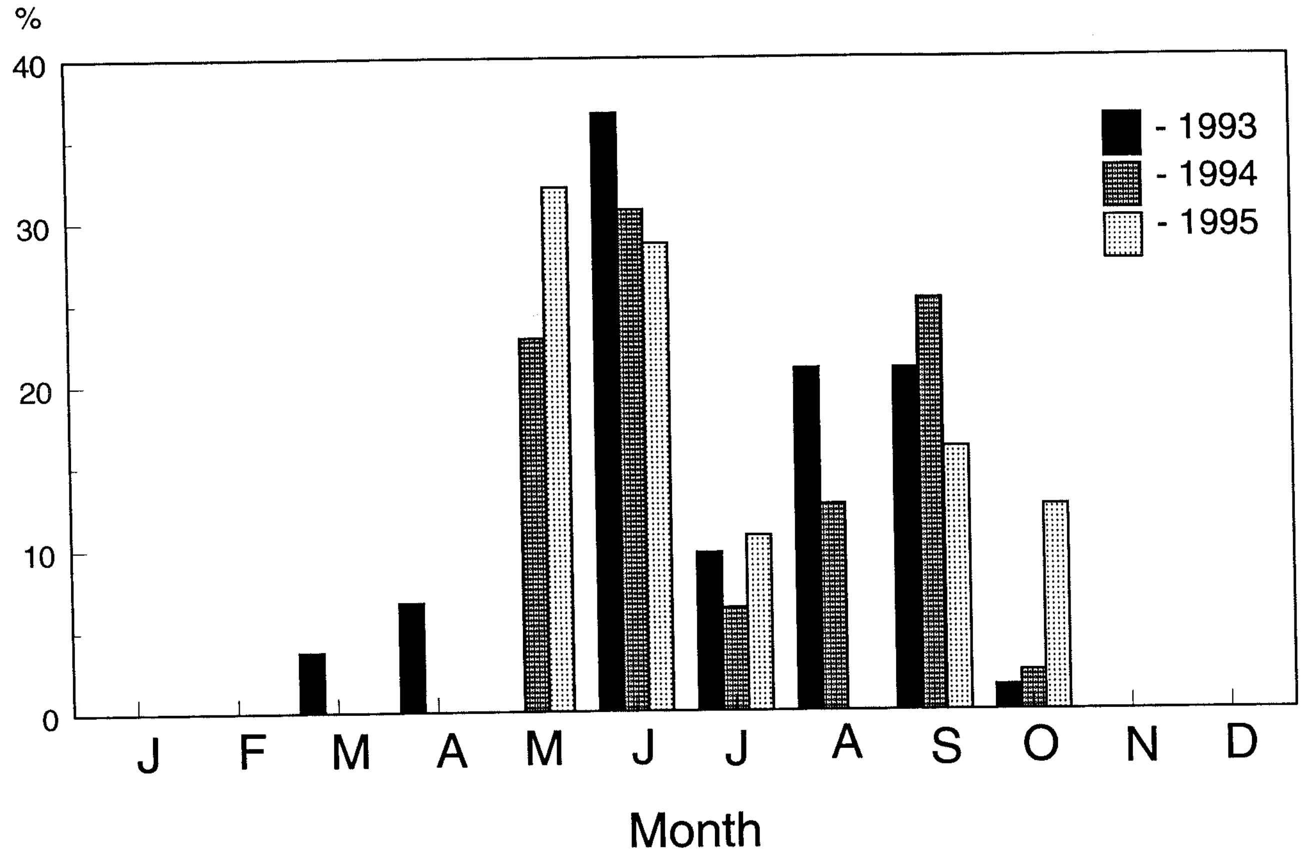

Figure 2. Monthly percentage of smooth snakes: 1993-95

As was clear from Tables 1 and 2, some snakes were captured more than once and so it was necessary to determine when 'new' individuals first occurred within the study area (Figure 3). Although these data indicate that the most important period for finding new individuals was also May and June they also show that new animals were found during every month of the active period (March-October). Since no visits were made during May 1993 it is likely that many of the 'new' animals recorded in June 1993 would have been found in May 1993 thus reducing the size of the peak in June. This would indicate that although both May and June are clearly key months for finding 'new' snakes, May appears to be particularly important.

How many site visits need to be made?

In order to estimate how many site visits need to be made before allo, or a high proportion of all the snakes present in an area, can be captured/observed, plots of the cumulative number of captures per array (by year : Figure 4) and complete study area (by year : Figure 5, and overall : Figure 6), resulting from 1-25/28 random site visits, were calculated using 100 to 500 random iterations of the available data.

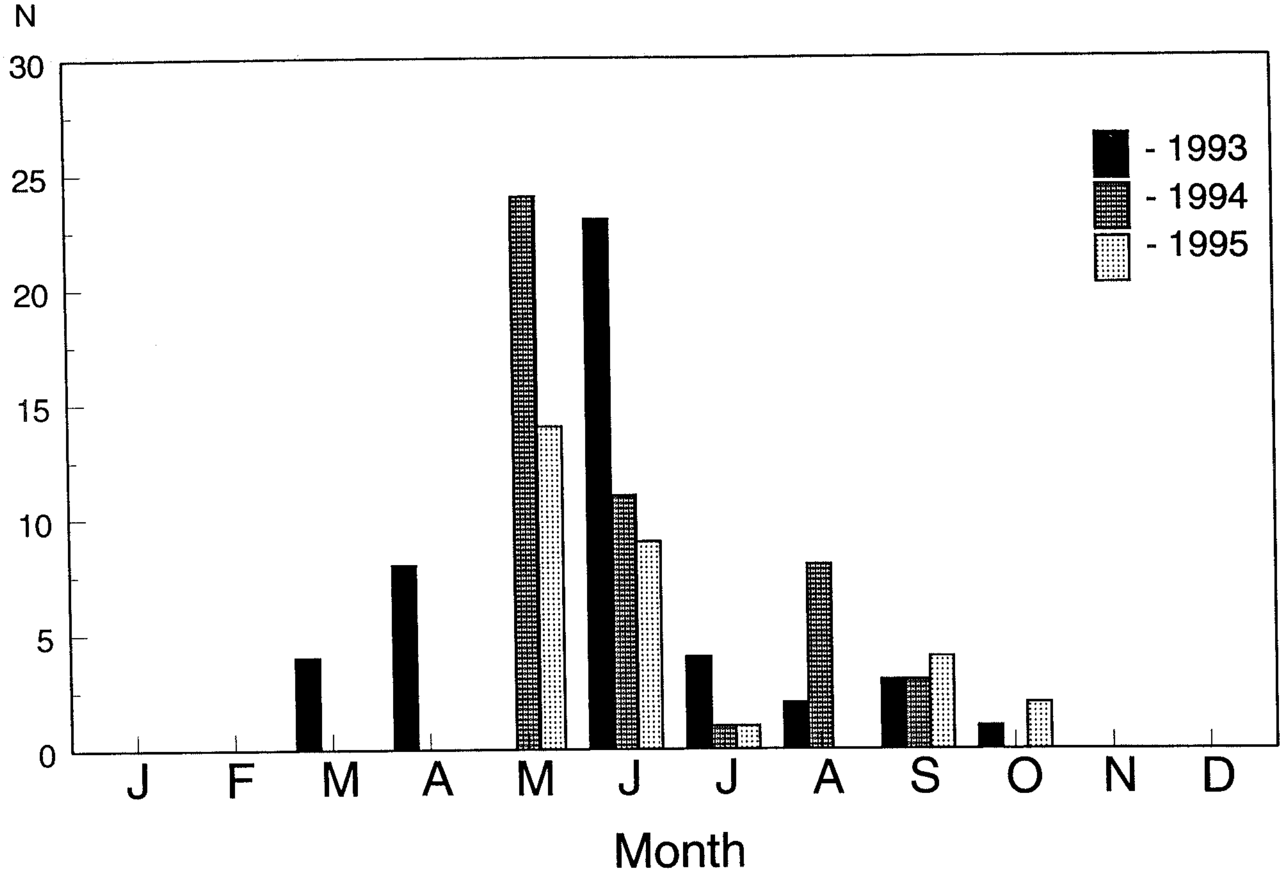

Figure 3. Monthly number of new smooth snakes (individuals): 1993-95

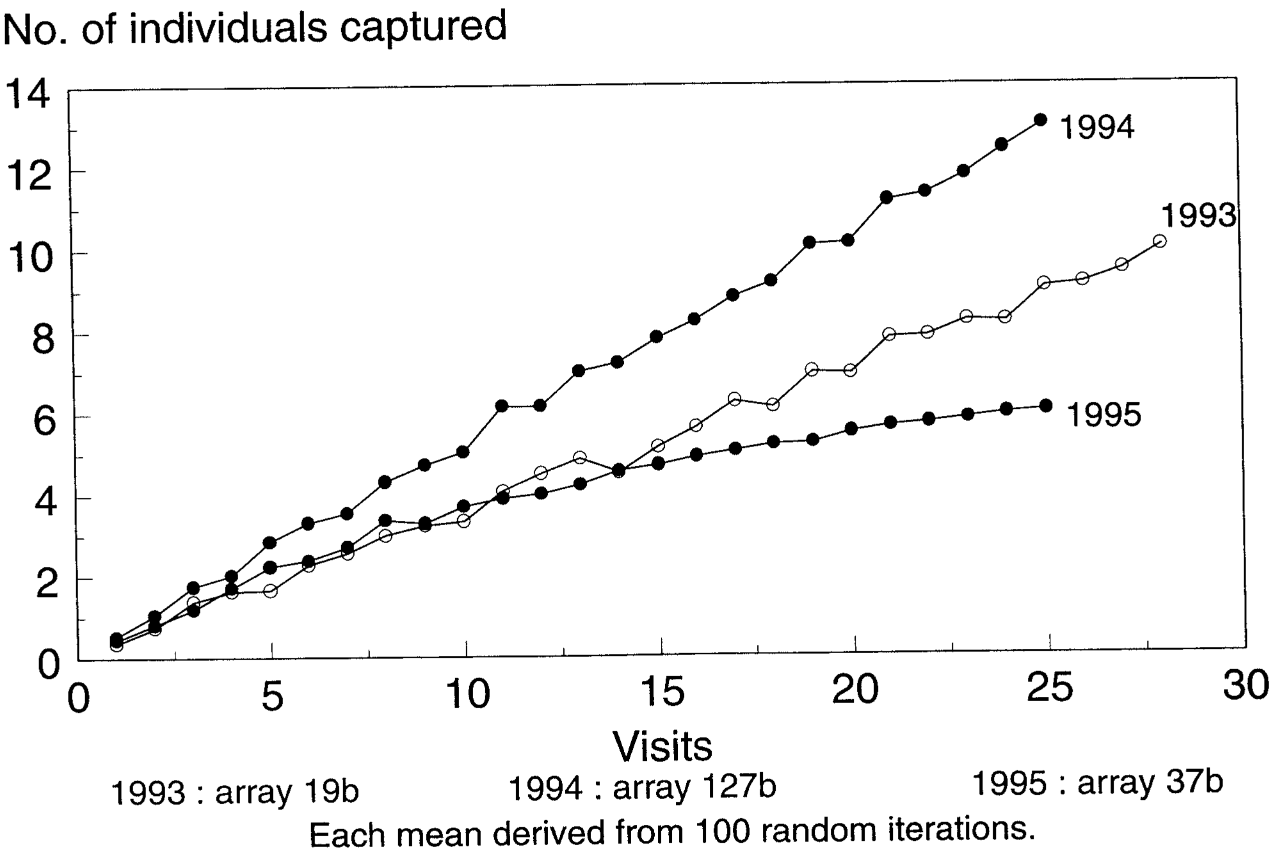

Figure 4. Cumulative individual captures of smooth snakes

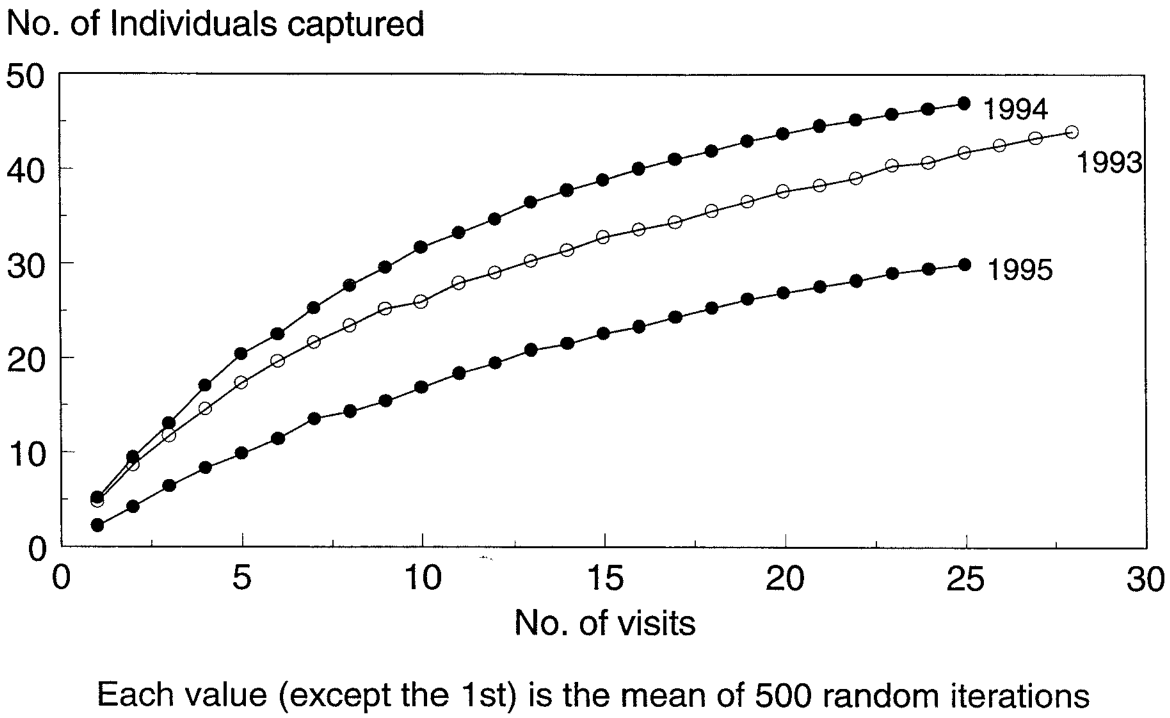

Figure 5. Cumulative individual captures of smooth snakes: 1993-95

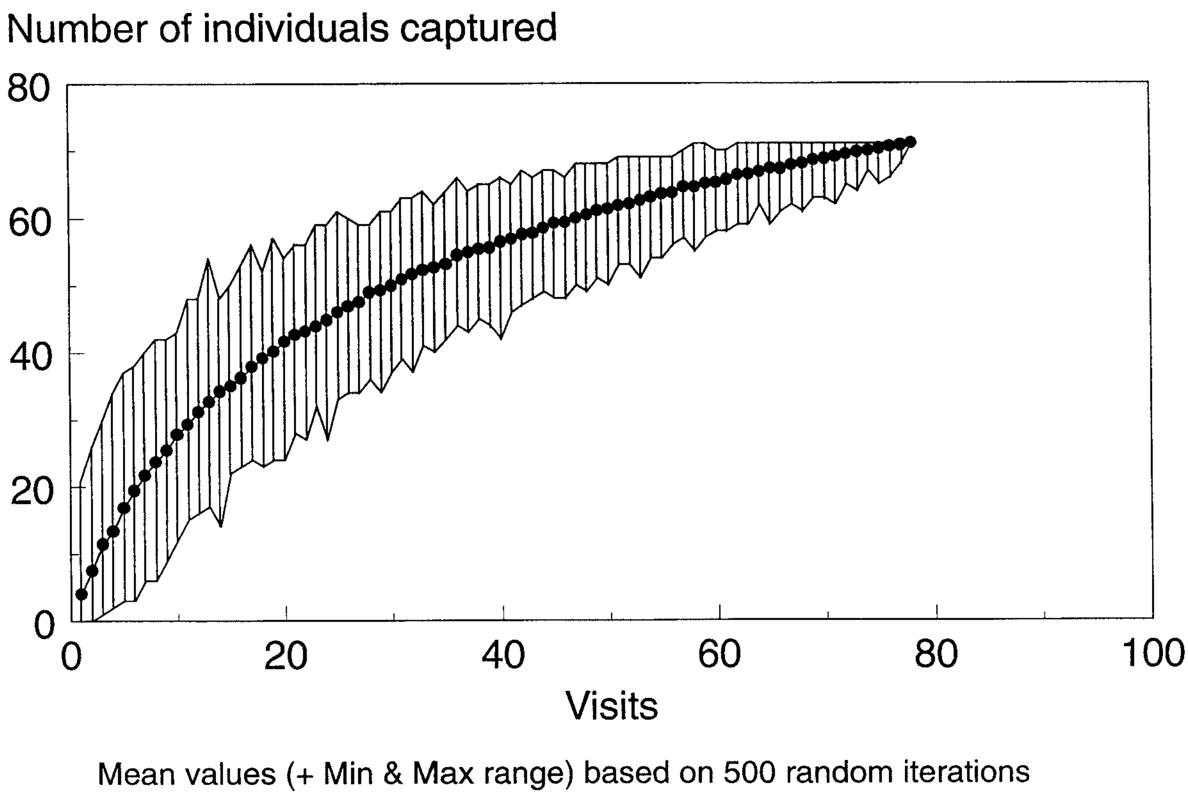

Figure 6. 1993-95 inclusive: Cumulative individual smooth snake captures

For example, a 19 refuge array on a section of heath in 1993 was replaced by a 127 array in 1994 and this in turn was replaced by a 37 array in 1995. For each year the total number of individuals found within an array was known and the number of random visits required to reach this maximum was plotted (Figure 4). The plots for 1993/94 both show that within the small area of a single array the number of individual snakes found continued to rise as the number of visits/searches increased. The plot for 1995 does appear to approach an asymptote but this may be a reflection of the very hot dry summer making snakes 'unavailable' for capture, using refuges, rather than the capture of all the snakes within the area.

When similar plots were done for the whole study area (based on 500 random iterations) for each year all three curves started to level off after about 15 visits (Figure 5) such that the range of values for the total number of individuals likely to be captured included the maximum possible. Similarly, between two and seven visits were required before this range included at least one individual, thus revealing presence of the species.

The slope of the cumulative plot (500 random iterations) for the whole study area over three years shows an even stronger tendency to approach an asymptote. However, the number of visits/searches needed before the range in values, for the total number of individuals likely to be found, included the maximum possible was about 58 (ie after at least two years). A minimum of three visits were required to determine the presence of at least one individual. An asymptote can never be expected to be reached over a time period of this length as recruitment into the PIT tagged population will be occurring as individuals within each cohort grown and attain the minimum size required before tagging can be done.

Discussion

Refuges are the easiest and simplest way of trying to answer the question most frequently asked by/of field herpetologists about the presence or absence of reptiles at specific sites of interest. They can be used by relatively untrained people and do not require 'field craft' expertise in order to find animals. They are, however, not equally attractive to all species. In this study the species most likely to be found using refuges were smooth snakes, slow-worms and grass snakes followed by sand lizards and adders.

Although the data analysed to date refer mainly to the smooth snake, the general principles are likely to be applicable to all six native species of British reptiles.

Presence/absence

For determining the presence or absence of reptiles at a site the number and layout pattern of refuges is not as important as the time of year when searching should be done. This study indicates that the best time to search for reptiles is during May, June or September. If searching is spread throughout the active period of March-October then a minimum of seven site visits should be made to maximise the chance of detecting reptile presence. Although the data from this study require further analysis it is likely that fewer visits/searches would be necessary to detect reptile presence if they were done during May, June and September. It is important to realise, however, that the failure to find reptiles at a particular site does not automatically indicate that they are absent from it, merely that they have not been encountered, and this can be the result of insufficient searching time, observer inexperience, inappropriate search conditions or badly placed/too few refuges.

Comparing sites

In order to compare the reptile fauna occurring at different sites the over-riding consideration must be the standardisation of the methods used at the different sites in terms of the number, density and pattern of refuges used, the number of searches made and the timing of the searches. At this stage of the data analysis it is not possible to define the number and density of refuges that should be used other than to recommend that refuges might be laid out in multiples of a 'standard' array. The 'standard' array will comprise a fixed number of refuges laid out at a set density in a hexagonal pattern and, ideally, each site would be visited/searched a set number of times (to be determined) throughout the period March to October. Data collected in this way would be comparable between both sites and years. Site visits made only during the best (May, June, September) or worst (March, July, August) months will result in biased data that will not be able to be used. Unfortunately surveys are frequently required to be done at such times and therefore further analysis of the data collected in the present study will attempt to provide a 'correction factor' for data collected in this way so that it may be able to be used. Although large sites would be surveyed using more arrays than small sites the data collected would be based on the 'standard' array and should, therefore, be comparable.

Population size

The methods required to determine the number of individuals within the population that are present at a particular site are similar to those used for presence/absence and population size, but more refined.

As large an area as possible (ideally all) of any suspected reptile habitat should be surveyed using arrays of artificial refuges. In general, the more refuges that can be used the better (but within reasonable/practical limits) as the chance of encountering reptiles will increase as the number of refuges increases. Individuals need to be identified and this is most efficiently done using PIT tags. However, these are relatively expensive and other less reliable and more time consuming methods may be used (eg back, belly, head and chin scale patterns). Toe-clipping in lizards and scale-clipping in snakes have been used in the past but are now required, by law, to be done under a Home Office licence and should only be attempted (if at all) by experienced herpetologists.

The present study has demonstrated that, in the case of Smooth snakes, sites need to be visited/searched during every month from March to October as new individuals may be encountered at any time. Most, however, are found during the months of May, June and September. If searches are not restricted to these key months, but are spread throughout the active period, then a minimum of about 15/16 visits need to be completed in order to maximise the chance of encountering all the snakes present within the study area or using it at some time.

Conclusions

The results (to date) of the present study suggest that although new individuals within a given reptile population may be encountered at any time between March and October, a high proportion will be found during the May, June and September when captures are also most likely to occur. The methods required to determine reptile presence/absence, population size and to enable comparisons to be made between sites are discussed and preliminary recommendations towards achieving a 'standardised' method for reptile surveys suggested.

[Editors note: the final report of this work has now been published as:

READING, C.J. 1990. Evaluation of reptile survey methodologies: final report. *English Nature Research Reports, No. 200*. Peterborough: English Nature.]

Discussion: Towards a standard survey methodology for British reptiles?

Steve Gibson: It seems there is a variety of survey needs. There's the simple presence/absence determination at a site of a particular species. The next step from that is to establish if breeding is taking place on the site. Then there can be attempts to quantify the population size and breeding success. The harder you work the better your estimates become, but as Chris has shown, we are never going to hone those down to particularly useful error terms. Then there is the application of the knowledge of the ecology of the species in being able to say how 'good' a population is or whether it is likely to persist in the long term, in the medium term or perhaps only persist for a short while. What would be useful for a national monitoring programme is presence/absence at as many sites as possible in different geographic regions of Britain. This may be sufficient on a national scale because you're not going to be able to say something every year about the status of populations on a regional basis; you may only be able to say it once every five years. For a planning and development application you would need that sort of basic information. In addition, as Tom was alluding to earlier, you would need more detailed inventory information. We really have to decide what questions we are going to want answers to before we decide about standard methods. We know what the limits are to survey methods. For example, the number of trained people that you can have on the ground, the number of days available for surveying, etc. But what are the questions that need asking?

Tony Gent: Does anybody have any comments on the kinds of questions that we need to answer by setting up standard methods.

Andrew Nicholson: One of the things that I'd like to point out is that all of the talks we've heard today have been about surveys and monitoring of reptiles on what we would think of as reptile sites. One of the things we don't think about so much is where we should actually monitor. Maybe if we are trying to establish whether there are long term declines in populations we shouldn't be looking at what are reasonably good reptile sites, but more at the more marginal habitats and the areas which perhaps don't look so good for reptiles to discover whether there are actually changes taking place there.

Steve Gibson: A good example of this is dormice turning up in honeysuckle hedges in South Wales. People just didn't think of looking there previously.

Tom Langton: As far as I see it, there are four principle questions. There is firstly the presence and absence information. There's the methods used to discover the distribution both within a particular site and also in a less focused way if you're looking at a general area. Then there's the question of population size and monitoring changes which perhaps needs a more details methodology. Lastly, there are the more unusual types of methodologies which mitigation projects might need. I can actually see four types of methodologies you would need to answer those four questions. For each of these four needs, I think we can divide the methodologies into two sub-sections. One for the snakes plus the slow-worm and one for the legged lizards. I think this is justified by the differing ecology and behaviour of these two groups of species, most notably due to their level of secrecy. So there are actually two x four, that is eight questions which could conceivably be asked and during the meeting have drawn us a two x four table which includes the best methods for each of those questions as I have picked up from the talks people have given today. [Editor's note: this table is included on page 156]

Tony Gent: Given that there are clearly very different questions and different resource levels, is there any merit in actually trying to devise a method which has a degree of standardisation in it? For example, we've heard about one method which may work very well for sand lizards but using that for slow-worms on a different site would clearly be very ineffective. From Chris Reading's research it would appear that you would need to use tins to survey for smooth snakes on his sites but, from my research on smooth snakes in the New Forest (where, admittedly, the habitat is very different and I did use fewer tins) I found most of the smooth snakes out in the open rather than under tins. [Editor's note: see Gent, Shewry & Spellerberg *this volume*, page 162]. Additionally, from radio tracking studies of over a thousand sightings, only one sighting was of a snake actually under a tin. Now whether this is a reflection of behaviour or whether it's down to differences in habitat I don't know but I tend to concur with Chris' view that, if you are looking for smooth snakes you would need refugia. The bigger issue is that, although there are several different groups of people out there looking, we do need more people doing survey field work. How do we improve the standard of consultants and volunteers and how do we improve the consistency of survey effort of even experienced herpetologists?

Steve Gibson: I think there are two types of 'standards'. Firstly the type which Tom mentioned before lunch which is effectively professional standards for consultants; the professional standards of those selling or offering their services to advise on planning and development in particular. The other is the set of questions which I mentioned earlier and which Tom firmed up. For presence and absence, could we perhaps get to a stage where we could say we are 70%, 80% or 100% sure of determining the presence of a given species at a given site? Perhaps a field trial is required to determine the effort needed for each technique to achieve different probabilities of detecting animals that are present. Then we can say that if you want to determine presence/absence on a site you have to use such and such a method as a minimum and then we could perhaps say if you want to determine the presence of breeding on a site you would have to do so much on top of that. How far we can actually take those questions I don't think we can answer at present.

Chris Reading: I think it depends to a large extent on the expertise of the people you are using. If you wanted people to go out and look for the sand lizard, the common lizard and, I would also include the adder, then you perhaps need 30 experienced people because I don't think tins are particularly suitable for these species. Therefore this needs experienced people. On the other hand if you're using tins which attract the smooth snake, the grass snake and the slow-worm then you don't need to be experts in fieldcraft to find the animals. The animals are either there or they are not when a tin is lifted. So therefore you have a much bigger pool of people that could be used.

Steve Gibson: That has two implications. One involves training and experience which Jim talked about this morning. One would hope that training leads to experience. The second point is what is actually achievable. The sand lizard is reasonably restricted. It doesn't necessarily need sheer weight of numbers of surveyors on the ground but the adder is a different proposition. It is quite widely dispersed. If you then need to use experienced people, it will mean that your design for a national or a regional survey would be very different. It occurred to me when Tom was reading out his four x two table of methodologies that the snakes and the slow-worm don't appear to be in the same category. I would agree with Chris that the adder appears to be slightly different again and perhaps there should even by a four x three table.

Tom Langton: I think you could actually fragment it up and have a different methodology for each species but, to be realistic, we have to simplify it somewhat. In my experience tins and wooden boards have been good for adders and these have also been useful for common lizards, contrary to what some people have been saying today, although they will often sit on top of the tin as well as underneath it. But I think in terms of doing, for example, the Key Reptile Site Register assessments and simple presence and absence assessments and also to a certain extent determining the distribution on a wider scale, then we've got to try and get one methodology for everything. I've actually found sand lizards underneath tins. Maybe I actually placed the tins on top of their burrows. I would say that the effectiveness of tins does fluctuate with weather and other factors. For the purposes of the local groups and others, one method is needed that can satisfy most of the people most of the time, even if it favours some species slightly over others. I would think that using tins or perhaps some other type of refuge substrate would be a suitable catch-all methodology.

Chris Reading: I think you're right. I'm just saying that refugia are particularly good for at least three species, less so for the adder and least useful for the two legged-lizards, for which you need more expertise and fieldcraft in order to find them. I've found sand lizards under and on top of tins, just like you have, but not very often and I think that this is the point. It's the difference between sightings associated with refugia and those in places where you might expect to see them, for example whilst walking transects.

Howard Inns: We have a lot of knowledge about sand lizards and we've got the resources to continuously monitor them. What we're short of is data about the other species. It seems to be utterly subjective looking for reptiles. For example, Tom was just saying he finds common lizards sat on top of tins. I don't. Everybody has their own methods of finding reptiles. I think the guidelines have to be generalised and I don't see why, if we're looking at the four more common species, the guidelines can't be extended to include additional notes on each of the four species' habits. They could give some additional guidance, for example if you think you might find adders on your site it might actually be worth going out earlier on a sunny day in March. To summarise, take the focus off the rare species, concentrate on the widespread species and provide additional notes that will help locate the different species. We also need to be clear about who we are preparing the methods for, what questions we want to answer and to encourage surveys in a variety of different habitats.

Jim Foster: I think the potential problems which Chris was spelling out, regarding refugia not picking up certain species mean that if we are advising on surveys for these species, we really have to spell out that surveyors have to look between the tins as well as underneath them. I think we need to go down the line which Howard explored with his draft which he sent out earlier this year wherein he spelt out the need to look at certain habitat features for example the interfaces, the edges of habitats, the banks and so on. I think this would help to get over the problem of a standard methodology at least for presence/absence surveys. If we have to point out that an old tree stump is equivalent to a tin then so be it. I don't think tins are the be all and end all of reptile survey.

Howard Inns: I've got copies of the methodology here if anyone wants it and I will revise it in the light of what we've heard today. [Editors' note: this is included as appendix to Howard Inn's paper, *this volume*, page 134].

Henry Arnold: As I see it what we need is to find out more about reptiles and to do that we need to get more people looking for reptiles. We've got to start with someone who's just joined the local reptile group and who knows very little about reptiles. So we should start of by encouraging these people to look at a wide variety of sites using guidelines and hopefully, with the encouragement from training days, and once we've got people out there looking and reporting in their sightings, you can start building up a picture in the county of where the reptiles occur. Once you've got something to show people, for example, all the grass snakes are in the south and all the common lizards are in the north, then you've got a peg to hang a project on. You could perhaps say well, we should be looking at these three particular sites where all surveyors who've visited have seen grass snakes and then you could use those sites for more detailed studies of monitoring, for example. We can't expect the beginner to go and put hundreds of tins out on a site. So by starting off gently with a simple study to find out, for example, where all the grass snakes occur in Northamptonshire, you might find out that the best sites to look are the old farm ponds marked on 1:25,000 OS maps. So that would be something simple to give to inexperienced surveyors to go and look at the rest of the ponds marked on the map.

Chris Reading: That's a slightly different question. It's about actually finding out where the animals are. Often the application these days is associated with developers who want to use a particular area of land and you have to establish the presence or absence of a species on the site. A different approach would be needed for this.

Tony Gent: Yet another approach would be similar to what Stuart was talking about earlier on, ie you have a piece of land and you are doing a particular management scheme on it, you want to find out whether the management is having any detrimental or beneficial effects on the reptiles. So you need to sort out the objective before you go about designing the method.

Henry Arnold: The point about that is that if you have good basic information about distribution at a county level, if you can say that 90% of the grazing marshes in this county have grass snakes and common lizards on them and the site that a developer wants to develop hasn't been looked at and is a grazing marsh, the chances are it's going to have grass snakes on so then at least you could put a marker on and say this is typical grass snake habitat for this county.

Tom Langton: But there's a huge danger there, in that that might not be the question that needs answering. It might be that we have to ask how important is this grazing marsh to grass snakes? I think we're in great danger of history repeating itself with what's happened over amphibians over the last fifteen years and that is that the national survey started off with a variety of methodologies. So, for example, some surveyors would go out in the daytime doing net surveys whereas others would go out at night with a torch and the result is we have a set of data derived from many different methods. That data is less valuable as a result of the methodologies not being more standardised. What you said about getting volunteers involved gradually, I'm not sure applies. I can see no better way of getting volunteers involved than letting them see them in large numbers at close range to start with and you will only get that experience if you use refuges. I think we should not be afraid of going straight to a fairly rigid methodology so that people's results fit into a pattern and can be compared from one region to another, otherwise we are going to continue to get what we have at the moment which is limited in as much as it's not comparable.

Chris Reading: It's meaningful in terms of presence/absence.

Steve Gibson: But it's out of date five years later.

Tom Langton: That may be true but what may be important is how many different places within a site have the reptiles been sighted? For example, this applies to Canford Heath at the moment. Not every part of the heath has been looked at and it is important to know where on the site the animals occur. It's far better to bring people in an organised fashion rather than conducting surveys in a more general fashion.

Howard Inns: If I understand correctly, Henry is trying to say that there should be a two phase approach. Phase one is to go out and search quite widely but if you find a grass snake on a particular site then look at that site more closely and see what you can find.

Tom Langton: I believe we need to get inexperienced people to work with and learn from experienced surveyors.

Henry Arnold: The problem there is that there are very few experienced surveyors at the moment so we are spreading ourselves very thinly. What I am trying to suggest is that we start off gradually and build survey effort up.

Tom Langton: In my experience the people who develop as surveyors are those who tag on the tail of experienced people and we've seen that with bats and birds. Unless beginners get in with the experts and watch them working they are probably not going to pick it up. We've seen many volunteers disappear from the scene because they didn't get enough sightings. So ideally they need to be paired off with somebody experienced in order to get trained up. Self-teaching probably wouldn't work without detailed procedures.

Henry Arnold: It's not entirely self teaching because there are people like Jim who can go round and train people. I'm not advocating that people necessarily train themselves.

Tom Langton: I think this comes onto another subject, which is that we're not yet equipped to train. Herp Groups of Britain and Ireland is moving towards that and we do have draft syllabus for reptile training but we do need to address issues such as training for trainers. The problem has always been that of catching the attention of people before they disappear. Once they are in and enthused then they often stay for life as many of the people around this table are a testament to.

Mabel Cheung: If you look at the Mammal Society they have done, for example, nut hunts for dormice. This was really just to raise awareness and I think that's the first thing we need to do. When people go out they first think of looking for birds and mammals but not necessarily for reptiles. We have to get the awareness first.

Chris Reading: We are mainly dealing with four common species. So for most people interested in wildlife I think it will be fairly easy for them to get involved as species identification is unlikely to be a problem.

Henry Arnold: I think the problem is that the four species we have are difficult to find. I wonder how many people in this room could put their hands on their hearts and say they could go out in summer and definitely find common lizards.

Tony Gent: What is important is how would you go about trying to find reptiles. Do you go to a 'guaranteed' tin or a 'guaranteed' bank where you are most likely to find animals? Perhaps we should be looking at those particular features to bring into the sampling regime. I was discussing with Jim earlier about the idea of logs for common lizards. Even in areas where it's difficult to find lizards if you chop down the tree, the next thing you know a common lizard is sitting on the log. Perhaps that was slightly flippant, but that is one approach to surveying, ie that there are various features within a habitat which we can look at to increase our likelihood of finding reptiles more efficiently, whether it's tins, particular features of a bank or fallen trees.

Jim Alexander: Looking less at the national perspective but rather considering small woodland blocks, for example, where I work. If I were to set out to help the foresters design a a plan to incorporate all aspects of conservation, my first approach to find out what's in there is not actually to do a survey, but to ask local people. We can get an awful lot of information from local people that maybe we don't know exists. You can get hold of this information simply be asking local natural history enthusiasts. If we then get the feedback that there have been sightings, we will then go in and take a closer look. This can save us an awful lot of time.

Chris Reading: I'd agree. I don't think tins are necessary at the first stage. They may be necessary when looking in a more detailed way at what's on a particular site. However, at a countrywide level I don't think you would necessarily need tins.

Jim Alexander: I think the idea of the nut hunt and the dormice and involving schools worked quite well. Maybe a similar approach is one way of getting more people interested and involved in reptiles.

Jim Foster: There are plans afoot for raising the awareness amongst the general public of reptiles. The common species project would like to write some general articles in the natural history press next year and then maybe broaden the appeal even further the following year to raise awareness of the importance of recording but I think here we need to know a bit more about specific survey methods. I think the tricky question which is on everybody's lips is how to quantify the importance of sites. I don't think you can get that kind of information from anecdotal hearsay reports. Although one off reports can be useful in terms of recording, there is a need for further detailed survey information.

Tom Langton: One of the things which Jim has been looking at is how lay people distinguish between the snakes and the slow-worm. The ability to identify species is a whole separate issue involving education and public awareness. I don't think that should detract us from the current issue which is the question of standard methodologies. The questions that most keen enthusiasts and local group personnel are asking is about presence/absence determination and assessing sites for Key Reptile Site status. We need a prescriptive methodology. Otherwise we run the risk of going down the same path that the recent amphibian surveys took and find we look back on the data and wonder just how useful it is.

Bill Whitaker: What worries you about the amphibian work which has been done? Is it that it missed too many presences or that it was non-quantitative? Surely a lot of good has come out of it despite the hotchpotch of methods used.

Tom Langton: This is not a criticism of individuals doing the work. It's not clear, for example, which are the best crested newt sites. A printout of sites and the number of newts seen doesn't mean very much because some ponds have been surveyed very quickly, whereas other sites have been subject to somebody studying very carefully. The lack of a standard methodology there has left us with a variable dataset and that is really only reliable for confirming presence.

Tony Gent: To some extent though, this links back to the question of the objective of your survey. We might not need a standard method for the lowest tier of survey. What we need to determine is where a particular methodology becomes appropriate. So if we're trying to get as many people as possible out looking while they are doing other tasks then probably tins aren't appropriate. Once a sighting has been made then a more objective method such as Tom was discussing would be appropriate.

Keith Corbett: I'd like to make one proposal and pose a question. They both involve regional herp groups which is a mechanism which has been set up with very good intention. To work as Howard was suggesting may come across problems because they are more amphibian than reptile based and this is more due to a lack of confidence rather than groups being conscious of the need for reptile surveys. The question is how do we get the county wildlife trusts more involved in the scheme? The proposal is if local herp groups are the catalysts to get more people involved in reptile survey, then we need to find a way to get those people trained fairly quickly and I think this isn't a matter of just getting ten or so to come to a certain area but rather to get a whole load of potential reptile surveyors to come to a very good reptile site and to come in good weather so that they will be guaranteed of seeing a lot of reptiles. I think we could do this by getting fifty odd people each time, bring them to Studland which has a very good reptile population and get them to walk transects across the site.

Tony Gent: We could even set up a standard reptile survey within a nature reserve such as Studland.

Keith Corbett: Well, I don't think it even needs to be as advanced as that. Speaking to some potential surveyors I get the impression that they lack the confidence to go out and identify these animals and the places where they are likely to find them. So I think one answer would be to get a group of people together just to see the animals in the first instance.

Tony Gent: I think that's a good idea and certainly one of the uses of National Nature Reserves is for education and scientific research. Perhaps we could even think about the next stage which would be to involve land managers who need to know whether the management practices they are using are having effects on reptile populations. A standard method there would be particularly important. More prescriptive methodologies would be useful.

Bill Whitaker: I'd just like to come back to the idea of transects. I'm still not convinced about how useful transects can be. The question I'd like to ask Chris is when you were going round your transects, obviously a lot of the time you were walking against the sun, I don't see how you can ever do effective reptile monitoring for species such as lizards without walking with the sun. I would have said that a lot of your effort as regards reptiles not using the tins would not have been so effective.

Chris Reading: I take your point. However most of the area that we were using had fairly low lying heather so the effect of shadow would have been relatively slight. Most of the sand lizards I saw, for example, were not underneath or on top of tins but were actually on the heather. One thing I would say is that I use my ears almost as much as my eyes. I am fairly confident that I picked up most of the animals that were there. Obviously I can't say categorically that I picked up all of them.

Tony Gent: I suppose there the trade off against efficiency is the ability to replicate the effort.

Bill Whitaker: If we're going to use transects we need to ensure that the route incorporates suitable herpetological features.

Chris Reading: Again this links in to what you're trying to determine. If you're trying to determine presence or absence then fine. If you're trying to determine something else, ie find out how many animals are present then that certainly isn't the best way of doing it because you need to account for other areas which may be used occasionally. Perhaps there are some animals which are sub-dominant and not allowed into certain areas, for example. You would miss those completely unless you looked in the less favourable parts of the site.

Tony Gent: Again that's the balance between maximising numbers seen per unit effort and some statistically significant idea of population size. I wonder if you would like to comment on your guidelines which we have already mentioned today, Howard, and whether you might consider modifying them after what's been heard today or perhaps send them out to people for comment?

Howard Inns: I certainly intend to modify the proposals which I made earlier on in the year and circulate them to ask for people's comments and then perhaps use the result as a basis.

Tony Gent: I see that as useful in terms of a step towards coming up with a universal method.

Jim Foster: I see Howard's proposals as a step towards an answer if not the answer, at least with regard to presence/absence determination. I know that when I first did the draft of the training course notes and showed it to a few people, often the reaction was that it seemed very subjective and there seemed to be a lot of notes about fieldcraft in there, for example to look at woodland edges, ie that the notes weren't particularly prescriptive. However I think we have to face the cruel fact that reptiles are difficult animals to survey and it may well be that we just have to point out to people these more subjective guidelines to maximise their chances of seeing the animals. Obviously, however, this is a problem when it comes population size estimates and other quantitative determinations. I think we still have a way to go on that issue.

Chris Reading: I'd like to make one point and that is that it is perhaps not necessary to try to cope with population size estimates at a given site so long as the methodology is repeated in the same way each year for a number of years and hopefully by the same person so that the expertise is standardised. The results obtained would then allow you to make comparisons, within the site over time.

Jim Foster: But this would only be relative comparisons within a given site.

Chris Reading: Yes, it would not give you figures on absolute population size.

Steve Gibson: In other words your inter-site comparisons would be less robust than intra-site comparisons.

Chris Reading: Yes, that's right because you're using different methodologies for different sites.

Tony Gent: I think we've had a fairly useful discussion. Thanks to everybody for turning up and contributing.

Additional papers not presented at the seminar

Reptile survey methods according to survey purpose

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Survey purpose	Species			
	Grass snake/adder	Smooth snake/slow-worm	Common lizard	Sand lizard
1. Rapid location of species	Tins and observation	Tins	Metal tins or other materials and observation	Observation
2. Population size estimate/ monitoring	Tins on grid; mark-recapture #	Tins on grid; mark-recapture #	Tins/materials on grid; mark-recapture #	Noosing and observation; mark-recapture on repeated routes #
3. Determining distribution on site	Tins and observation according to time constraints	Tins then observation if tins not possible due to site constraints	Tins/materials and observation according to time constraints	Observation
4. Translocation project *	Metal tins set to density and mark-recapture as appropriate #	Metal tins set to density and mark-recapture as appropriate #	Metal tins to set density and observation #	Noosing and observation #

* may also be supplemented by various reptile trapping methods in association with drift fence or tins.
# marking includes pattern/scale counting/scale damage description for future recognition of individuals.

Notes
For (1), try to do four visits per year as a minimum. Two before the end of May and a further two before the end of September. Try to survey when shade temp is between 10 and 23 C, and avoid windy days. Disguise tins with dead grass/vegetation if necessary. Remove when survey is complete.

Record the following:
1. Weather conditions (sun/cloud pattern, wind speed, shade temperature, general humidity)
2. Time of day and hours on site
3. Days since last rainfall (n)
4. Soil type(s)
5. State of vegetation under tins
6. Density of tins (needs method to define site boundary and recommended tin density for survey purposes 1-3)

Try to keep standard:
- a) tin size (m^2) (plus smaller tin for sites with public access)
- b) tin thickness (mm) (avoid the heavy gauge galvanised sheeting)
- c) degree of rust/age (tins should be weathered with more metal than rust)

The Spring behaviour of Adders, *Vipera berus* on Cors Fochno, Dyfed, and implications on survey methodology

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Introduction

Information on the distribution of the four common British reptiles is largely dependant on incidental sightings, with few sites having any more information than just the species' present. The ability to assess and compare populations of reptiles on different sites, requires some form of quantitative data. The ability to confirm that a species is not present on a site would also be very useful.

Prestt (1971) describes the behaviour of adders around hibernacula in spring as they emerge from hibernation and disperse locally into surface dens and lying out areas. Frazer (1983) noted that a dozen adders will spread out over about 1ha. and bask for long periods until they slough their skins and begin courtship.

Whilst most serious reptile survey work is carried out in March, April or September, this is usually because animals are lethargic and at their most visible, but rarely are further inferences drawn on the locations of hibernacula or population size.

The intention of this study was to investigate the feasibility of using the known habits of adders particularly in the spring to provide more quantitative data on their population size and distribution on a particular site. Additional ecological and behavioural information that would increase the efficiency of future reptile surveys was also sought.

The ability to identify individual adders provides good evidence of behaviour and seasonal distribution. However the time taken essentially confines it to intensively studied sites and academic works. In this study it was the intention to try and identify individuals by any appropriate means, including sketching and photographing head markings.

Site and methods

Cors Fochno is a large raised mire in West Wales, consisting of a large area of *Sphagnum spp.* turf which gives way to *Calluna vulgaris, Myrica gale* and areas of *Mollinia caerulea* tussocks around its edges.

It was known that all four of the commoner species of British Reptile occurred on the site, although little was known about their population size, distribution or seasonal behaviour. Prestt (1971) describes a wetland site where adders migrate seasonally to dryer areas for hibernation, and it seemed likely that a similar situation could exist on this site.

Due to the extent of the site and the shortage of time available (1 field season), it was decided to concentrate the study in an area, slightly raised above the water level on the northern edge of the site, about 3 ha in size.

Preliminary survey work carried out in March and April revealed areas where adder basking was concentrated and their behaviour in these areas was described, and habitat details taken.

These sites and the surrounding areas were then thoroughly searched in order to find more dispersed individuals.

A fixed route which included these sites and a representative sample of other habitats present in the study area was walked regularly over the six month period between March and August and any reptiles seen were noted. Between them, the sites were checked 122 times over the six months period.

Results

Seven areas where adders could be regularly found basking during March and April were located. Adder behaviour in these areas was found to be remarkably constant at this time, and their presence could be almost guaranteed in almost all weather conditions. They appeared very lethargic and could be easily located and approached.

Figure 1 shows the average number of adders seen on each visit to the seven spring basking areas, with site 1 containing the largest number of animals (at least 9).

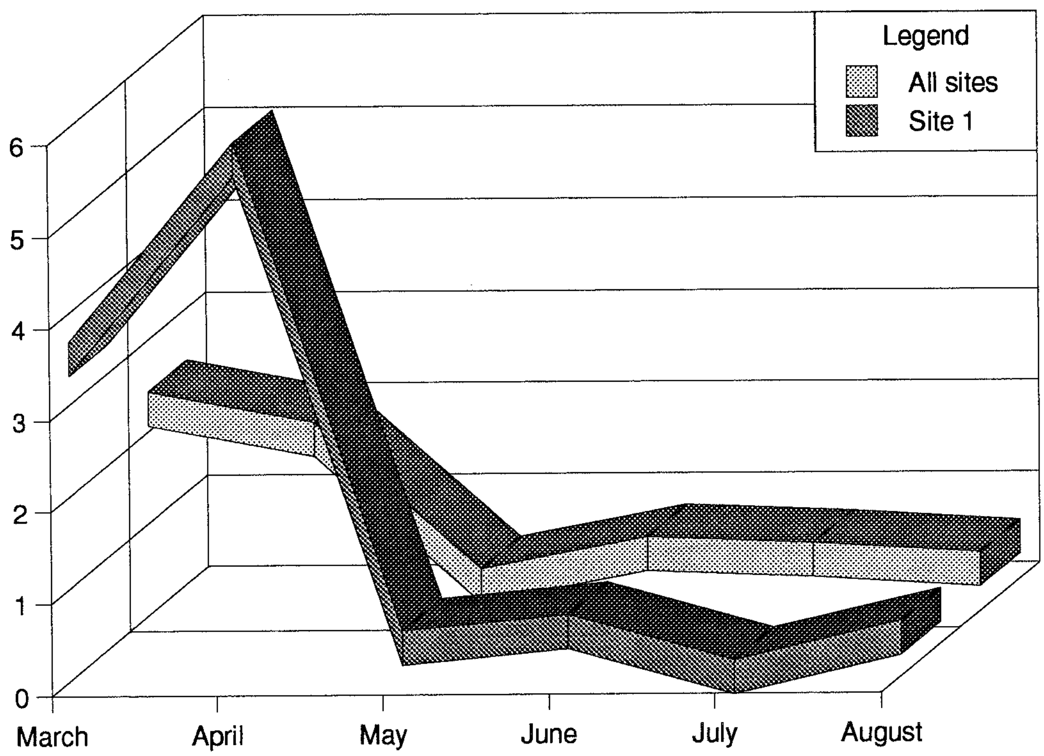

Figure 1. Average no. adders/visit

In early spring the numbers recorded slowly increased as they came out of hibernation. Obvious changes from sluggish to more active behaviour became noticeable as the spring progressed and they warmed up.

At site 1, where nine animals were seen on one occasion, they could all be found in and around an oval clearing in an area of tall *M. caerulea* tussocks. The clearing was about three metres in length and on flat damp ground with a carpet of various moss species. The furthest that any of these animals were seen from this clearing was about 10 metres. There did not appear to be any obvious dispersal of males into outlying territories, certainly in the earlier part of the spring, with males and females often lying intertwined with each other in the clearing.

On about 19th April those that had emerged first, started to slough their skins and begin courtship. By regularly visiting the same sites, it was possible to tentatively identify individuals by their activity, assisted by use of head markings. By the start of May, the numbers of animals found in these areas had dropped dramatically. Very few adders were located in other parts of the study area while walking the fixed route, although other reptile species were recorded.

The features of the seven sites varied quite substantially, both in habitat, and numbers of animals using them. Despite being on slightly raised ground, 6 of the sites were in wet areas where opportunities for underground hibernation were limited. It was thought that in some areas, hibernation actually took place in the bases of the tussocks above ground level. There were few common features to the sites, although they were often adjacent to ditches and trees.

A number of sloughed skins were recovered from around the spring basking areas. By cutting them along the ventral surface and opening them out, it proved possible to identify the individual that it came from, using the markings. (See Figure 2.)

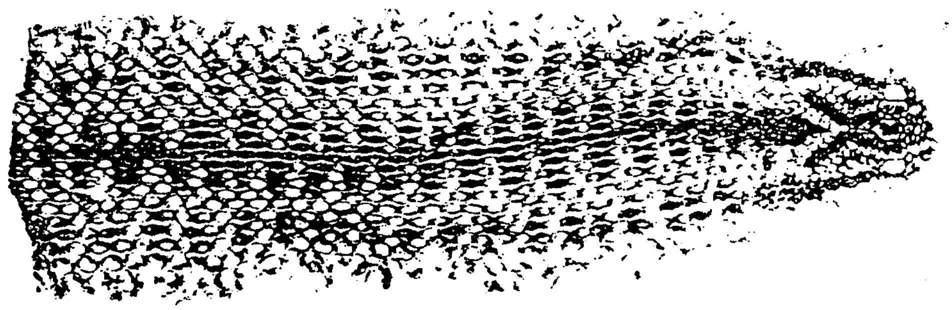

Figure 2. The head section of a sloughed skin recovered on 12th May at site 5.

Conclusions

The ease with which adders basking in the spring around their hibernation sites could be located and monitored in all but the worst weather conditions makes more quantitative survey work possible. Furthermore knowing that if adders are present on a site they will be almost certainly basking is very useful for timing and designing reptile survey work. It also allows tentative conclusions to be made on the absence of the species, when none are discovered after systematic searching in March and April during suitable weather conditions.

Locating basking sites and then carrying out a detailed inventory of the animals present at each site will then give an estimate of the size and structure of the population. The results obtained in a single season on Cors Fochno enabled the distribution and numbers of adders and their hibernacula to be mapped within the very small study area (Elliott, 1994), although it failed to provide any information on seasonal movements.

The merits of using hibernation sites to provide more quantitative data on adder distribution are listed below:

Advantages

- ❑ Animals can be located without disturbing them even in fairly dense 'noisy' vegetation or in poor weather conditions, while they are still lethargic.
- ❑ Enables the assessment and monitoring of population size and structure if the majority of hibernacula can be found.
- ❑ Systematic surveys in spring may be the closest way of confirming presence or absence of adders on previously unsurveyed sites.
- ❑ Possibly allows individual animals to be monitored annually, particularly if individuals use the same hibernation site in successive years.
- ❑ Research on a site can be easily expanded to include the study of spring behaviour around hibernacula. This could include further work on the correlation between basking habits, weather conditions and time of day.
- ❑ Enables site managers to protect basking adders from disturbance when they are at their most vulnerable, and to manage hibernacula sensitively.
- ❑ The sloughed skins collected from around hibernacula can be used to confirm the presence of an individual animal at a particular site.

Disadvantages

- ❑ Survey work has to be concentrated on a very short period in the spring, and again possibly in the autumn, and the sites need to be located early in this period in order to obtain sufficient information.
- ❑ Finding a reasonable percentage of the hibernacula in often dense undergrowth can take a considerable length of time.
- ❑ The combination of the above two factors seriously limits the size of land that it is possible to survey in a year. Consequently an accurate census of the population may only be suitable for sites where intensive surveys are possible.
- ❑ Repeated surveys carried out in dense vegetation in March and April may lead to the disturbance of nesting birds.

- It seems unlikely that this method will work for the other species, thus forcing surveys to be carried out for each species separately. Despite thorough searching, no regular basking sites for grass snakes were found in this survey. This may be due to them occurring at lower density on this site, or that they choose to hibernate in different habitats .

- This method does not take account for migration between hibernating and summer feeding areas.

Prestt (1971) described the dispersal of adders into surface dens in the vicinity of the hibernacula, with males setting up territories almost immediately after emerging from hibernation. This did not appear to be the case on this site and this could have implications for survey methodology, with the identification and study of individual animals around hibernacula forming the basis for the study of a population. Further work should be carried to discover how this behaviour varies between sites.

Similarly surveys are usually carried out in the most productive weather conditions in order to increase the size of the usually small datasets, but few attempts have been made to research exactly what conditions are best and to standardise survey methodology.

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Activity of the smooth snake: observations of animals in the field and their relevance to developing a survey technique for the species

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Introduction

Smooth snakes were studied during a three year investigation (between April 1984 and October 1986) into their ecology, and especially their movement behaviour and aspects of their thermal ecology. During this period radio-transmitters were attached to some of the animals for short periods of time. This allowed much a much more detailed study of the animals behaviour than had previously been possible by allowing regular repeat observations. A previous assessment of the effects of transmitter attachment showed them to have a negligible effect on the animals' behaviour (Gent & Spellerberg 1993).

The observations made during this study can be used to help understand the behaviour of these animals and may help to develop survey methods to allow their further study.

Methods

Smooth snakes were studied intensively at two sites in the New Forest, Hampshire, although casual observations from three other sites in the New Forest have been included in this analysis. Whenever a smooth snake was observed in the field a series of measurements were taken. Each animal was assigned a unique identification number and on first capture would be sexed, weighed, measured and marked by scale clipping (animals over 8 cm total body length only). Body temperature at capture, shaded air temperature (at 1.5 m above ground in the experimenter's shadow) and 'bask site temperature' (ie, the temperature of the location of the animal or an equivalent spot in terms of angle, shading, etc, if the animals was not to be disturbed) were taken and cloud cover described in eighths.

Direct observation of smooth snakes can be difficult and is prone to observer bias. Searching for smooth snakes can be facilitated by positioning 'refuges' on site. 'Refuges' are defined here as a variety of different materials including corrugated tin sheeting (of various sizes), concrete tiles and roofing tiles, rubber matting and pieces of wood. No fixed grids were placed at the two main study sites during the study and the number of pieces of material were added to during the three year study. At Site One up to a maximum of 77 refuges were placed in an approximate area of 27 ha and at Site Two up to a maximum of 32 refuges were placed in an area of about 40 ha. Refuges were not even distributed in these areas but rather were placed in areas that were most studied or that seemed to offer a good opportunity of finding animals.

Other tins were placed at some of the other sites that were visited far less frequently. These were primarily to investigate differences in habitat use by placing similar grids in different types of habitat. At Site Four for example, eight grids each of six tins, placed at an interval of 10 - 15 metres apart, were placed down in an area of about 17 ha. At Sites Seven and Nine eight grids of six tins and seven grids of six tins were placed respectively. No snakes were seen at Site Nine; however smooth snakes were recorded at a further site (Site Five) where no refuges were laid.

During this study no attempt has been made to quantify search effort. Consequently 'visual' observations of smooth snakes can be considered 'casual observations'. A total of 408 'visual' observations of smooth snakes were made at all sites. However it is possible to be look at more systematic searching using radio-telemetry.

Some animals were fitted with radio-transmitters (see Gent and Spellerberg, 1993, for details) which were left attached to the animals for between 0.07 and 9.71 days (mean 4.72 ± 2.81 days). Animals with radio-transmitters attached were located every 2 hours (± 1 hour) and the animal's behaviour observed, its position described relative to a grid devised for each site, and environmental conditions (shade air temperature, bask site temperature (recorded in °C to one decimal place accuracy) and cloud cover) recorded. Observations where the animals became snagged, or that were otherwise considered unrepresentative as a consequence of the methodology, were discarded. A total of 1297 usable radio-tracking observations were made.

In this analysis we look at the observations made of smooth snakes by 'visual' searching and by radio-tracking. We accept inherent biases in the 'visual' data, this being dependent on observer effort. However, because of a the large number of observations and the fact that these were collected over a three year period of field work, it does give an indication of when animals were seen and, especially, when they used refuges. Radio-tracking data allows a more systematic description of when animals are visible and when they are not. While these data do not allow rigorous statistical analysis, collectively they can be used to gain a greater insight into smooth snake activity and allow a description of when survey is best undertaken to maximise the chances of finding this species.

Results

Data presented graphically are given as absolute numbers of observations. To aid interpretation we recommend comparison of relative heights of the bars across the distributions.

1. Visual observation data

Of the 408 observations made of smooth snakes by direct observation, 346 (84.8%) were of animals in the open and 62 (15.1%) were of animals below some form of refuge. Not all observations had temperature data associated with them. The median shade air temperature for animals in the open was 18.7°C (range 9.6 - 26.3°C; n= 332);the interquartile range was 16.9- 20.4°C which represents the typical 'mid-range' of shade air temperatures when snakes were seen. Extremes of air temperature can be excluded by deleting the upper and lower 5% of observations (ie. the 5th and 95th percentiles) : the 5%-ile was 13.8° and the 95%-ile 22.6°C. For those snakes found below refuges, the median shade air temperature was 19.8°C (range 11.1- 26.7°C; n= 57), the interquartile range was 16.3 - 21.9°C, the 5%-ile was12.9° and the 95%-ile 23.8°C. The frequency distributions of numbers of observations versus shade air temperature (for each of the methods) are presented in Figure 1. These are combined data for both sexes, immatures, all sites and the whole activity period (April to October).

The associated median values of the ground temperatures at the location of the snakes were 21.4°C (range 7.8 - 36.3°C, n= 331), the interquartile range was 18.8 - 23.0°C; the 5%-ile was 15.2° and the 95%-ile 27.1°C) for snakes in the open and 21.8°C (range 12.6 - 29.7°C, n= 57, the interquartile range was 19.0 - 24.7°C, the 5%-ile was 13.4° and the 95%-ile 28.1°C) for snakes under refuges.

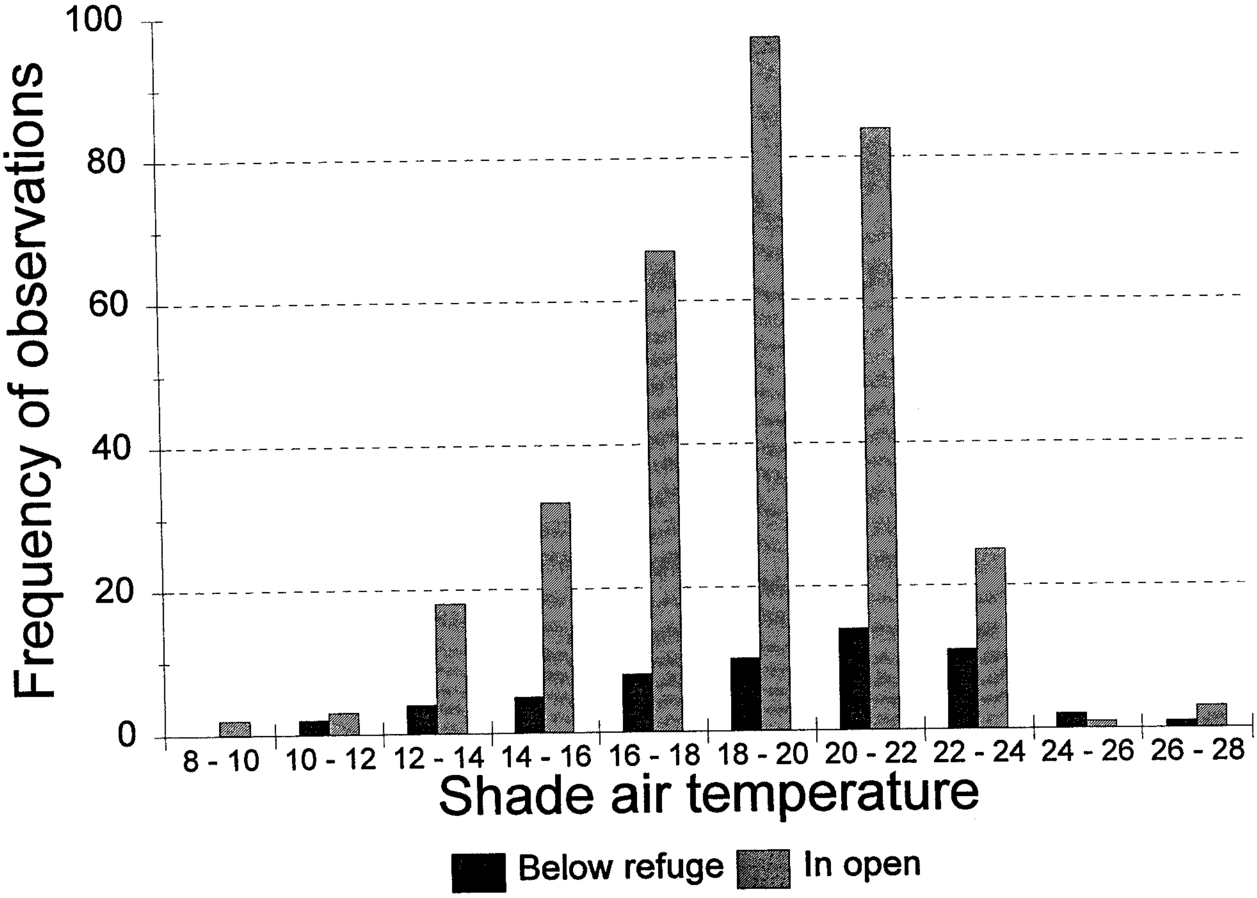

Fig. 1 : **Frequency of observations of 'visually located' smooth snakes seen under refuges and in the open against shade air temperature (°C)**

Cloud covers (recorded in eighths) at the time of capture of 'visually' located snakes are shown in Figure 2 for snakes found below refuges and for those found in the open.

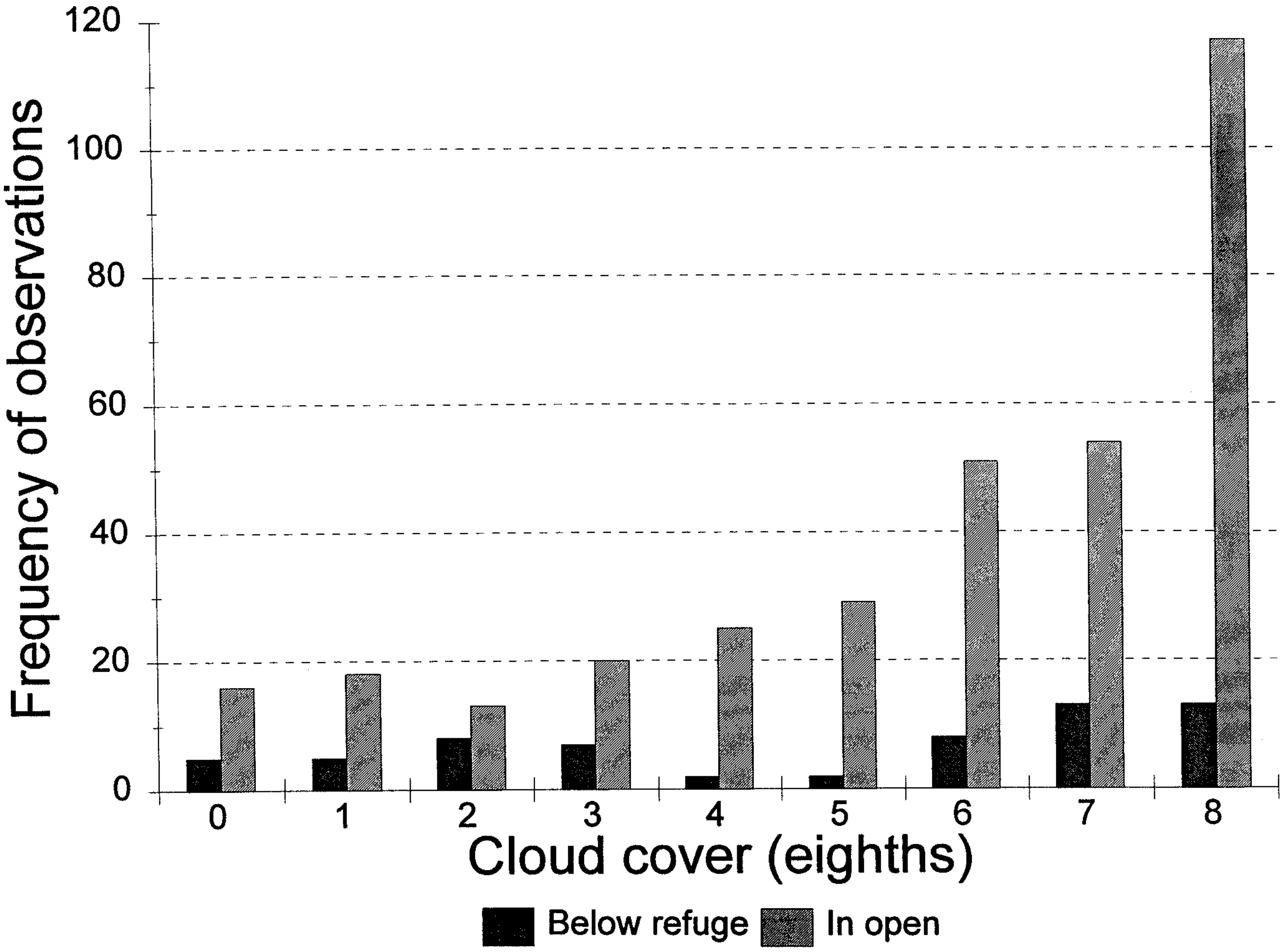

Fig. 2 : Frequency of observations of 'visually located' smooth snakes seen under refuges and in the open during different extents of cloud cover (measured in eighths)

By separating the 'visual' observation data into two hourly time categories an indication of the times when animals demonstrated observable activity, and when they used refuges, can be obtained. These data are in Table 1.

Table 1 : Frequency of 'visual' observations of snakes below refuges and in the open in each of seven different two-hourly time periods showing percentage occurrence of observations within each time period.

Time (BST)	'Visual' observations below refuges (% of observations in time period)		Observations of animals by 'visual location' (%of observations in time period)		Total observations in time period
0801 - 1000	0	(0.0)	33	(100.0)	33
1001 - 1200	11	(12.2)	79	(87.8)	90
1201 - 1400	10	(11.0)	81	(89.0)	91
1401 - 1600	8	(10.7)	67	(89.3)	75
1601 - 1800	13	(16.7)	65	(83.3)	78
1801 - 2000	17	(44.7)	21	(53.3)	38
2001 - 2200	3	(100.0)	0	(0.0)	3
Totals	**62**	**(15.2)**	**346**	**(84.8)**	**408**

Sorting the data by season allows an overview of how refuges were used at different times of year. Seasons are defined Spring = March, April and May; Summer = June, July and August; Autumn = September and October. See Table 2.

Table 2 : Frequency of observations of snakes below refuges and in the open in each season. Percentage occurrence of observations within each season are given

Season	Observations below refuge (% of observations in season)		Observations of animals by 'visual location' (% of observations in season)		Total observations in each season
Spring	7	(11.9)	52	(88.1)	59
Summer	42	(16.9)	206	(83.1)	248
Autumn	13	(12.9)	88	87.1)	100
Totals	62	(15.2)	346	(84.8)	408

2. Radio-tracking data

Of the 1297 radio-locations of smooth snakes, 809 (62.4%) were of animals not visible to the eye (ie where 95% or more of the animal's body was obscured below ground, under cover or 'buried' in vegetation). These animals could be considered impossible to locate by 'visual' location during survey. On one occasion only an animal with a radio-transmitter attached moved under a refuge. A further observation of a radio-tagged snake below a refuge; in this case the animal was released there and remained for a sufficiently long period of time to be recorded over two hours post release. In 488 cases (37.6%) the animals were considered 'visible', though whether all of these would be detectable by survey unaided by the radio-tracking equipment is doubtful. Median shade air temperatures for 'visible' snakes was 19.4°C (range 11.6 - 30.5°C, n= 483) and for those that were considered not visible to the eye 17.6°C (range 8.0 - 31.9, n= 785). The frequency distributions of observations of 'visible' and 'not visible' snakes during different shade air temperatures are presented in Figure 3. Using the interquartile range for 'visible' snakes (to show 'typical' shade air temperatures) indicates that snakes were most likely to be seen between 17 and 21.8°C. For 'visible' radio-tagged snakes, the 5%-ile was 14.9° and the 95%-ile was 25.6°C. These indicate the extremes of temperatures below and above which snakes were only infrequently seen. The associated median values of the ground temperatures at the location of the snakes were 21.0°C (range 12.0 - 34.0°C, n= 483) for snakes that were 'visible' and 17.0°C (range 8.5 - 35.8°C, n= 785) for snakes that were not visible. For 'visible' radio-tagged snakes the interquartile range of 'bask site' temperatures was 18.3 - 23.5°C, the 5th and 95th percentiles were, respectively, 15.5° and 27.8°C.

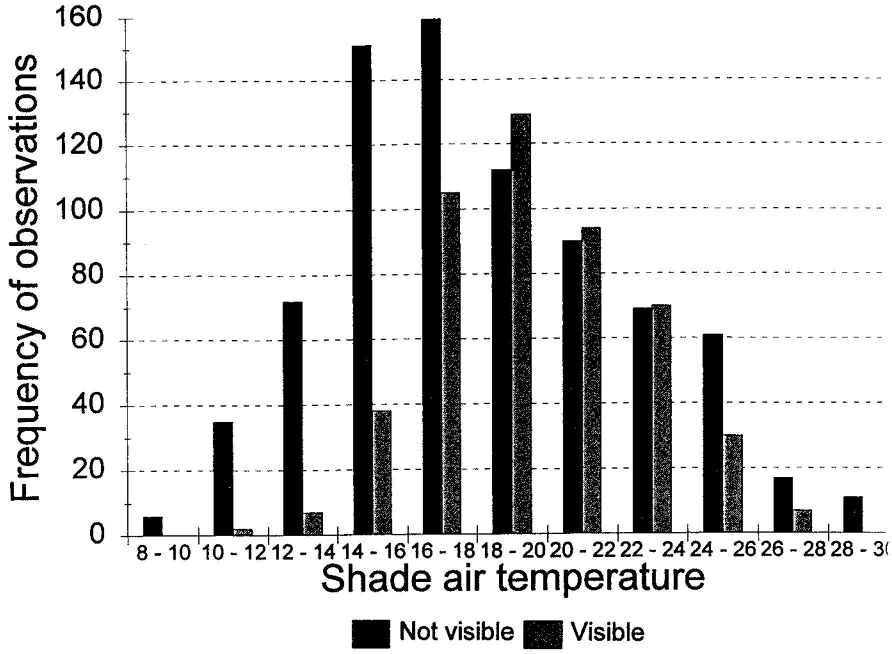

Figure 3. Frequency of observations of radio-tracked smooth snakes (i) that were not visible and (ii) that were visible to the eye on location during different shade air temperature (°C)

Cloud cover recorded on location of radio-tagged smooth snakes is presented in Figure 4, showing numbers of animals that were 'not visible' and that were 'visible' on location.

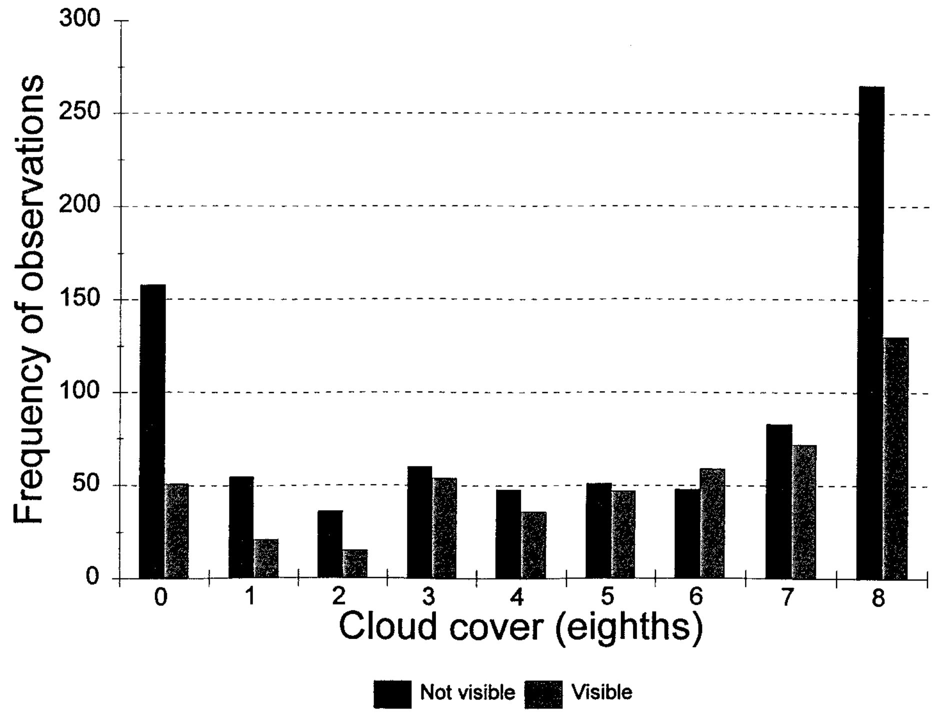

Figure 4. Frequency of observations of radio-tracked smooth snakes that were not visible and that were visible to the eye on location against degree of cloud cover (measured in eighths)

Radio-tracking data were separated into two hourly time categories to show how the ability to observe animals varied over time; these data are presented in Table 3.

Table 3. Frequency of observations by radio-tracking of snakes that were 'not visible' and those that were 'visible' in each of eight different two-hourly time periods. Percentage occurrence of observations within each time period are given

Time (BST)	Snake 'not visible' (% of observations in time period)		Snake 'visible' (% of observations in time period)		Total observations in time period
0601 - 0800	19	(90.5)	2	(9.5)	21
0801 - 1000	107	(68.2)	50	(31.9)	157
1001 - 1200	113	(55.1)	92	(44.9)	205
1201 - 1400	96	(44.7)	119	(55.4)	215
1401 - 1600	88	(43.6)	114	(56.4)	202
1601 - 1800	112	(58.0)	81	(42.0)	193
1801 - 2000	212	(88.0)	29	(12.0)	241
2001 - 2200	62	(98.4)	1	(1.6)	63
Totals	809	(62.4)	488	(37.6)	1297

Division of the data by season allows an overview of how ability to observe animals varies with different times of year. Seasons are defined Spring = March, April and May; Summer = June, July and August; Autumn = September and October. See Table 2.

Table 4. Frequency of observations by radio-tracking of snakes that were 'not visible' and those that were 'visible' in each season. Percentage occurrence of observations within each season are given

Season	Snakes that were 'not visible' (% of observations in season)		Snakes that were 'visible' (% of observations in season)		Total observations in each season
Spring	103	(76.9)	31	(23.13)	134
Summer	467	(62.5)	280	(37.5)	747
Autumn	239	(57.5)	177	(42.6)	416
Totals	**809**	**(62.4)**	**488**	**(37.6)**	**1297**

3. Body temperatures

Body temperatures of visually located snakes were recorded at each capture by inserting a quick-acting 'shulthers' thermometer into the snakes cloaca. Similarly, body temperatures were recorded at the end of radio-tracking sessions. However, to ensure consistency, these data are kept separate in this analysis. The median body temperature for visually located snakes in the open was 24.1°C (range 10.5 - 31.1°C, n= 265) whereas that for snakes found below refuges was 24.0°C (range 14.2 - 31.6°C, n= 30). Radio-tracked snakes that could be located visually had a median body temperature of 22.2°C (range 13.8 to 29.0°C; n= 18) while the corresponding value for those that were not visible when captured was 19.3°C (range 13.1 - 29.4°C; n= 7).

The frequency distributions of these data are presented in Figure 5.

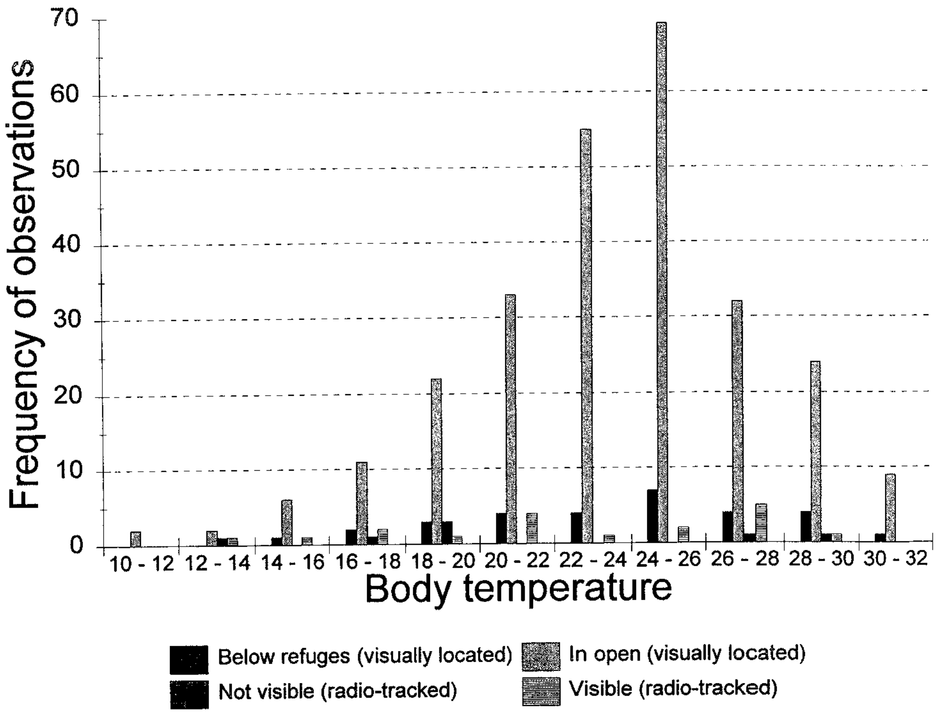

Figure 5: Body temperatures (°C) of smooth snakes located by 'visual searching': (i) below refuges; (ii) in the open and of radio-tagged animals: (iii) not visible to the eye, (iv) visible to the eye immediately prior to capture.

Conclusions

While recognising the limitations of these data analyses we believe, nevertheless, that it is possible to draw general observations which have practical implications for survey and monitoring.

We have chosen to undertake only simplistic analysis of weather variables and have avoided the complexities of investigating interactions between variables (eg temperature and cloud, season and time of day). This was partially due to insufficient data to allow such study. But it is also because the intention of this paper is to look at quite simple relationships in such a way that the likely affect of each can be considered and used to guide survey effort. More detailed study would also require data from other parameters not studied and would yield a highly complex model.

Visual searching records

1. Visual location gave a smaller total number of sightings than radio-tracking. Visually located data will be more prone to observer bias than radio located data. Only 15.1%

of visually located snakes were under refuges; the majority of snakes that were located by this method were in the open.

2. No simple relationship was apparent between shade air temperature and use of refuges or of occurrence in the open. There was a slight tendency for refuges to be used at slightly higher shade air temperatures 16 - 22°C and for animals to be in the open (mostly basking) at lower temperature 16-20°C.

3. Median temperatures of the location of snakes (ie. the bask site temperatures) were very similar for animals below refuges and in the open. Yet the range of temperatures below refuges were smaller than were the ground temperatures associatedd with animals located in the open. Refuges were used when temperature below them ranged between 12.6 and 29.7°C. Typically refuges were used when the temperature below them was between 18 and 24°C, and generally not used when <13° or >28°C. It is likely that at cooler temperatures snakes bask in the open to benefit from the more rapid warming offered by direct insulation. At higher temperatures (>28°C) snakes are approaching their upper thermal limit (maximum tolerated temperature) and will elave to find cooler sites.

4. While no clear relationship seemed to be shown between finding snakes below refuges and changing levels of cloud cover, there seemed to be an increasing number of snakes seen in the open with increasing levels of cloud.

5. In general refuges were used most in the early evening, between 1800 and 2000. Except for early morning and when they were not used at all, there was an approximately even, low use of tins throughout the remainder of the day. The exception to this were the three records after 2000 hr (all were of snakes under concrete refuges that retained heat for longer than elsewhere and so remained warm after the warmth of the sun had gone).

6. There was little seasonal variation between the use of refuges. Looking under refuges was marginally more successful method for locating snakes, relative to locating animals in the open, during the summer than in the other seasons. The difference though was very small.

Radio-tracking data

1. Smooth snakes were visible only for about a third of the time; only 38% of locations were visually observable. Observation occurred only during daylight hours and therefore excluded the major period of inactivity overnight. These observations support previous comments that this species is 'secretive' in its behaviour. This was noted by Spellerberg (1977) at Hartland Moor when, despite intensive study having marked many animals, many large unmarked animals were still located following a fire.

2. The combination of the 'visible' and 'not visible' data shows that radio-tracking effort was conducted when shade air temperatures varied between 8.0 and 31.9°C. A comparison of the observations obtained by radio-tracking relative to shade air temperatures indicates that there is an overall similarity in frequency distribution of visually locatable animals and animals that cannot be seen.

3. Snakes were visible over a range of shade air temperatures; equally they are not visible over a similar, though broader range of temperatures. However there was a

tendency to be able to see more animals at slightly higher temperatures 17 - 22°C, than at lower temperatures 15 - 22°C. Smooth snakes tend not to be visible at the extremes of temperature <14° and >25°. The proportion of snake locations that were visible rose to over 50% between 18°-24°C and became notably more reduced as temperatures increasingly became lower or higher than this range.

Corresponding bask site temperatures best for seeing smooth snakes are 18 - 24°C; with few snakes being seen when the area occupied by the snake was <15°C or >28°C.

4. No simple relationship was apparent between cloud cover and the ability to see radio-tagged smooth snakes, though the greatest proportions of visible snakes were on fairly cloudy days with between five- and seven-eighths cloud cover.

5. Snakes were more likely to be seen early to mid-afternoon (1200 - 1600 hr). An increasing number of locations were 'not visible' in the earlier and the later parts of the day.

6. Radio-tagged snakes were more likely to be visually locatable during Autumn than in Summer and in Summer more so than in Spring.

7. Radio-tracking indicates that snakes only rarely selected refuges (only 2/1297 locations (0.002%). As a proportion of 'locatable snakes' this represented 2/488 (0.004%) - still only a very small proportion. At sites like those studied in the New Forest, with relatively low numbers of refuges, visual searching for basking snakes proved to be most productive.

Body temperatures

1. Overall there was little difference in recorded body temperature of snakes below refuges and those found in the open. A slightly greater proportion of snakes had higher body temperatures (nearer the laboratory determined 'preferred temperatures') below refuges than in the open. This may be a consequence of being able to regulate temperature without needing to trade this off against visibility. Smooth snakes are considered to be cryptic 'heliotherms'; that is they warm by basking but aim to be cryptic. Hence they frequently 'mosaic bask' and are hard to locate. There is therefore a behavioural trade-off between optimal body temperature (as determined by other studies) and cryptic behaviour.

2. The field body temperatures of snakes that are not locatable could not be determined during this study. It is possible that those animals that could be located were, in general, 'warming up'.

3. The implications for survey are that animals are more likely to be seen when they need to be in the open or below refuges in order to warm up. It is presumed that once at the preferred body temperature snakes do not stay in the open but rather hide away or forage for food (which may be below ground in litter or in low dense, prostrate vegetation).

General comments

1. This study plays down the value of refuges; these sites were intensively studied and, in the absence of a rate of capture index it is hard to draw too many conclusions about

how valuable the use of refuges is. This project did not attempt to quantify the relative merits of different techniques at the outset.

2. The vegetation at the sites was relatively open and visual searching was comparatively easy; searching also favoured specific spots where animals were likely to be found or known to be present and therefore is intrinsically biased by observer effort and perception.

3. Given their secretive behaviour, the use of refuges is the only practical way to find smooth snakes in many vegetation types, especially where obvious featurezs for searching (banks, interfaces between vegetation of different heights) are not present.

4. Well placed pieces of tin at other sites visited since the completion of the above study have proved the most effective way of finding smooth snakes; especially where there is no prior knowledge of specially favoured areas or of 'key features' on the site. Such tins are often placed on southerly slopes or in areas of mature, structurally varied vegetation.

5. No attempt has been made to assess the interaction of different weather variables to describe how these affect survey success. Clearly factors such as cloud cover, wind, preceding weather conditions, etc, will affect ground temperatures and humidities and hence the behaviour of snakes and, in turn, the ability to survey for them.

Guidelines for smooth snake survey based on the conclusions of this study

1. Survey undertaken for smooth snakes in southern England was most successful when the ground temperature or temperature below refuges are 18 - 24°C. (It is possible these observations are not applicable elsewheres in the snake's geographic range).

2. Corresponding air temperatures were between 16 and 22°C..

3. Cloudy warm days were best for seeing smooth snakes.

4. This was when animals were warming up, but not too warm to be fully active

5. Snakes were active and visible at all times during daylight but mostly between 1000 and 1800. Mid-morning to the middle of the day was when most snakes were visible.

6. Survey effort should be concentrated in Autumn when snakes appear to be more easily seen.

7. Refuges were a useful technique for allowing a cryptic species to be located; these were used mostly when temperatures were 18-24°C. However they seemed to be used relatively infrequently. There seemed to be little variation in use of refuges between seasons.

8. Even in ideal conditions a large proportion of animals will always be undetectable to the observer.

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The value of motorway verges for reptiles - a case study

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Introduction

Of the six terrestrial (non-marine) reptiles in England, the smooth snake *Coronella austriaca* and the sand lizard *Lacerta agilis* receive full protection under Schedule 5 of the Wildlife and Countryside Act (1981). This rendered unlawful the selling of these species, their intentional killing or injuring, and the damaging of, destruction of, or disruption of access to, any site which they use for shelter or protection. Since 1981, it has become progressively more likely that surveys and mitigation programmes will be carried out in the threatened heathland habitats where these species are found. By contrast, scheme-specific survey for the relatively more common snakes and lizards has, until recently, been undertaken in very limited basis.

These relatively more common species, namely the viviparous lizard *Lacerta vivipara* the slow-worm *Anguis fragilis*, the grass snake *Natrix natrix* and the adder *Vipera berus* were protected under the WCA (1981) only against unlawful sale. With the issue, however, of the Variations of Schedule Orders in (1988) and (1991) the wilful killing or injury of these species was also rendered illegal. Protection was not extended to their habitats. Nevertheless, the practical effect of this change has been to increase considerably the risk of legal prosecution run by developers, should they elect to implement development projects in areas of habitat for any reptile species, without first undertaking scheme-specific survey, and proposing agreeing and carrying out appropriate mitigation where reptiles are found.

The Guidelines for Ecological Inputs to Environmental Assessment produced by the Institute of Environmental Assessment in 1994 advise that survey should be undertaken in sites where any species of (protected) reptile is suspected and for which previous survey data are unavailable.

Roadside verges, which frequently contain mixtures of rank grassland and scrub, are often cuttings or embankments with sunny south and south west-facing slopes. They have for some time been considered to support habitat for lizards (Leighton 1903, Smith 1969) and in urban areas slopes along road and rail corridors may represent a significant part of available habitat to snakes and lizards (Langton 1991).

There is an increasing number of reports to support the contention that the slopes and edge habitats associated with major transport corridors (road and rail) habitats in Britain already harbour valuable reptile populations.

As with railway lines, the restriction of access to motorway and many trunk road verges for safety reasons, the steep slope and noisy environment of motorway verges results in their being infrequently visited by people. Even the 1993 English Nature publication *Roads and Nature Conservation* places relatively little emphasis on reptiles, especially those only partially protected under the WCA. The combination of the British Government's motorway widening programme, the publication of the Department of Transport's Design Manual for Roads and Bridges, and the developments in legislation and professional guidance just described have led to the present study along part of the M4.

Study Area

The survey relates to a 10 km section of the M4 in an area where the motorway traverses a largely open landscape of mainly arable farmland, punctuated by occasional areas of low-density human habitation. No heathland occurs along the scheme, although areas of acid grassland do occur. The verge varies considerably in width about an average of approximately 10 metres (see Photos 1-3).

The verges are 22 years old and have developed into a sward dominated by rank false-oat grass *Arrhenatharum elatius* and a variable scrub cover of planted and self-seeded shrubs and trees, frequently dominated by bramble *Rubus fruticosus* agg. Features such as roadside ditches, embankments at overbridges add topographical and vegetational heterogeneity.

The soils throughout the study area are gleys belonging to two series. In the centre of the study area the M4 traverses, for approximately 2.5 km, a zone of argillic gleys of the Hurst Association. The Soils Survey of England and Wales (SSEW) describes this as 'a coarse and fine loamy permeable soil mainly over gravel variably affected by groundwater'. Elsewhere in the study area, the M4 traverses an area of stagnogley soils of the Wickham 4 Association, described by the SSEW as 'slowly permeable, seasonally waterlogged, fine loamy over clayey and fine silty over clayey soils'. In general, the soils in central part of the study area are generally drier and more freely draining than those at either end.

Methods

Metal tin reptile refuges (corrugated iron sheets cut to approximately 1 m^2) were placed at survey sites on the north and south verges of the motorway. At each site, either one or two tins were placed on the ground and anchored with tent pegs to prevent their displacement by wind or the suction forces of large vehicles. The distance between sites averaged approximately 500 m, but the distance varied between 100 and 800 m, so that tins could be placed in those micro-habitats considered the most likely places for reptiles to occur. These were generally places sheltered, to some degree from wind by virtue of topography or shelter from trees, yet with patches of open vegetation exposed to sunlight for much of the day, acting as 'sun traps' or reptile 'basking' locations, and towards the edge of the highway boundary. All tins were located in long grass, adjacent to areas of scrub.

In total, 69 tins were placed at 40 sites; 21 to the north and 19 to the south of the motorway. All tins were visited on each of six different survey days between the 1 June and 5 July inclusive. Some tins were visited twice on the same survey day. Visit times were selected as far as possible to coincide with suitable weather conditions and times of day when tins could be expected to be acting as heat traps and for reptiles to be attracted to shelter beneath them. When reptiles were found, age and sex was noted if possible, to assist in estimation of total numbers of different individuals of each species seen at each site to be summed over all visits.

a.

b.

c.

Photos 1-3. Typical habitat where reptiles were found to be present within the highway boundary (a & b) and not found (c)

Observations of any reptiles seen basking in vegetation by surveyors in places close and to between the locations of tin placement were also made. Habitat type outside the highway boundary adjacent to the tin placement sites was classified into three categories: woodland, pasture or arable land. Percentage scrub cover 20 m either side of each sample site was estimated by eye. Sites were also classified according to whether or not they were adjacent to a motorway ditch supporting aquatic vegetation. Ditches were typically 2 metres wide and one metre deep.

Results

General

A minimum of 35 individual reptiles were located. Three species of reptile; slow-worm, adder and grass snake were found to be present. Reptiles were found at 14 of the 40 survey sites (35%; see Table 1).

Table 1. Numbers of sites where reptiles were found and numbers of reptiles found at each site

	Slow-worm	Adder	Grass snake
Number of sites where found	12	4	1
Total number of individuals counted at all sites, summed over all survey days	49	9	6
Minimum number of different individuals found	27	6	2

At no single site were all three species found together, although at one site a young adder was found under a tin with four slow-worms (a male, a female and two juveniles). No viviparous lizards, smooth snakes or sand lizards were seen at any of the sites. Most reptiles were found under tins. Slow-worms and grass snakes were only seen under tins, while only half of the adder sightings were under tins.

The presence or absence of reptiles and their numbers at each site were examined in relation to four factors: the presence or absence of a motorway ditch supporting vegetation, the soil type, the nature of the adjacent habitat outside the highway boundary and the percentage scrub cover in the vicinity.

For each site the maximum number of different individual slow-worms seen, per tin, on any one visit was calculated. Account could not, unfortunately, be taken of 'turnover' of reptiles under tins between visits because the identification of individuals from age/sex etc. was carried out only at some sites. The means (± standard errors) of these site totals are presented broken down by each of the four factors listed above in Tables 2 and 3.

Table 2. Number of slow-worms found at survey sites in relation to the presence of a good ditch, soil type and scrub cover on the verge

Mean number of slow-worms at survey sites		Significance Test (Mann-Whitney U)
Ditch 0.89 ± 0.29 (n = 16)	No/poor ditch 0.04 ± 0.04 (n = 24)	U = 69 p<0.0001
Relatively freely draining soil 1.28 ± 0.40 (n = 12)	Poorly-drained soil 0.13 ± 0.08 (n = 28)	U = 55 p<0.0001
< 35% scrub cover 0.35 ± 0.19 (n = 23)	> 35% scrub cover 0.43 ± 0.18 (n = 17)	N.S.

Table 3. Number of slow-worms at survey sites in relation to the habitat type outside the highway boundary

Woodland	Pasture	Arable	Statistical test Kruskall-Wallis
1.5 ± 0.56 (n = 6)	0.52 ± 0.31 (n = 13)	0.14 ± 0.1 (n = 21)	H = 8.26 p<0.02

Slow-worms were found to be most numerous under tins at sites next to vegetated ditches, on relatively freely draining soils. There is also some evidence that slow-worm numbers were affected in some way by the adjacent habitat outside the boundary, with sites adjacent to land under arable cropping being least favoured.

The similarity of the relationship between reptile occurrence and ditches and soils results from the fact that the area of vegetated ditches were, like the area of argillic soils, largely confined to the centre of the study area. The data in the cells are not distributed normally and the considerable overlap of argillic soils and vegetated ditches results in there having been only two sites on stagnogley soils with vegetated ditches. Parametric analysis of variance techniques of analysis could not, therefore, be employed. The means of slow-worm counts at sites next to ditches may, however, be compared between soil types (Table 4).

Table 4. Numbers of slow-worms at survey sites next to good motorway ditches in relation to soil type

Relatively freely-draining soil	Relatively poorly-draining soil	Statistical Test (Mann-Whitney U)
1.33 ± 0.41 (n = 10)	0.16 ± 0.11 (n = 6)	U = 8 p<0.02

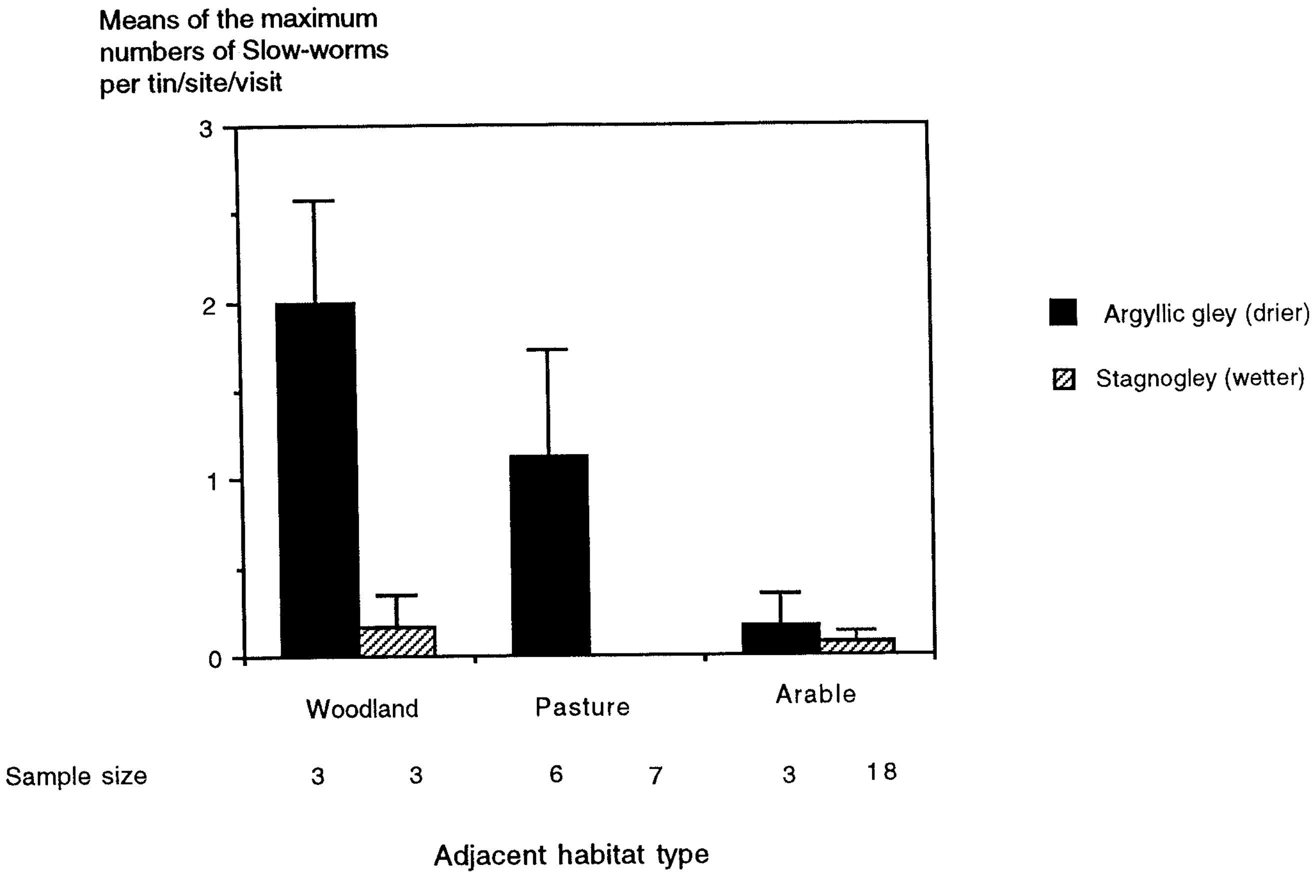

Figure 1. Slow-worm numbers along the motorway verge in relation to soil type and adjacent habitat type outside the highway boundary

There is a suggestion, therefore, that soil type affects distribution even between sites adjacent to vegetated ditches.

The interaction between soils and adjacent vegetation type is presented graphically in Figure 1. The plot shows that any effects of adjacent habitat type would appear to be similar on both soil types. The differences between slow-worm numbers in the area of argillic gley adjacent to the different habitat types was not quite significant (the sample size being quite small: Kruskall -Wallis: $H = 5.53$, $n = 12$, $p < 0.07$).

A similar analysis could not be carried out for adders as there were too few sightings of this species. All sightings, however, were on the argillic gley soils, adjacent to vegetated ditches ($p<0.01$, Fisher's Exact Test). The greatest concentration of adders was noted adjacent to a conifer tree plantation.

Calculation of means (± standard errors) of percentage scrub cover at the different survey sites expressed for each adjacent habitat type and soil type are shown in Table 5.

Table 5. Percentage scrub cover along the verge adjacent to sample sites in relation to soil type and adjacent habitat type

Soil type	Woodland	Pasture	Arable	Total
Argillic Gley	30 ± 10 (n = 13)	35 ± 6 (n = 6)	57 ± 23 (n = 3)	39 ± 7 (n = 12)
Stagnogley	33 ± 20 (n = 3)	24± 5 (n = 7)	33 ± 5 (n = 18)	31 ± 5 (n = 28)
Both types	32 ± 10 (n = 6)	(29 ± 4 (n = 13)	36 ± 5 (n = 21)	33 ± 3 (n = 40)

Percentage scrub cover was very similar for all sub-groups and was, therefore, considered unlikely to have had influence on reptile distribution between sample sites.

Discussion

The greater abundance of slow-worms and adders in the area of motorway verge associated with better drained soil types might be anticipated from the reported preference of reptiles for well drained soils (and particularly sandy soils: see eg Smith 1969) which do not get waterlogged easily, and are less compacted. Slow-worms would also be expected to favour sites adjacent to ready supplies of their invertebrate prey, and the motorway ditches support relatively good populations of invertebrates such as molluscs. It would be worth exploring three possible effects further at other sites.

A causal relationship between numbers of slow-worms and adders and the degree of draining in gley soils would be of interest, given the close similarity to the soil types in question. More widespread correlation analyses between distribution of these species in relation to variations in similar soil types could perhaps provide further insights into the role soil type plays in the natural distribution of reptiles, their ability to colonise disturbed or newly constructed habitats and perhaps even to influence the carrying capacity of sites.

The apparently greater abundance of reptiles on sites adjacent to the more stable and structurally diverse/species-rich habitats of woodland and pasture as compared with arable land, suggests that there is likely to be interchange of both reptiles and their prey between verge and adjoining habitats. Regular disruption of adjacent habitats as occurs by ploughing, rolling, and cropping on arable land - and possibly other factors including agricultural sprays and their secondary effect on reptilian prey - may all have effects limiting the reptile populations on the motorway verges.

In the present study all sample sites were chosen in areas with habitat characteristics suitable for reptiles. As motorway verges mature over time, various successional processes take place, including colonisation by woody species which eventually, as open patch size decreases, may make the habitat less suitable for them. Given the large area of this type of habitat that has been created in the UK over the last 40 years, it would be interesting to compare reptile occurrence on a widespread sample of motorway verges, to see how verge age, soil and vegetation type influence numbers, distribution and movement of reptiles on a wider scale. As is the case with railway embankments in the long term, it is the methods of management that will become increasingly important to the continued presence of reptiles.

The study as a whole appears to add new evidence that motorway verges can include valuable terrestrial habitats for reptiles. This is an important finding with the national implication that, although motorways may act as barriers, preventing reptiles from crossing them, if they are carefully designed and maintained they may provide refuges in which reptiles may survive and along which they may interchange with other areas. The large number of reptiles found also vindicates the expending of public resources by the Department of Transport in scheme-specific survey effort for reptiles, in habitats where protected species are expected to occur.

Managers of motorway and other types or road verges might be encouraged to survey and identify areas where reptiles occur and to develop management plans to maintain a network of suitable conditions for reptiles along identified stretches of roads. Such management may be less costly in the long term than maintaining areas of tree planting along road edges, in places where planting is not required for screening and noise reduction purposes.

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