Population structure and translocation of the Slow-worm, *Anguis fragilis* L.

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ABSTRACT — Proposed redevelopment work in Petersfield, Hampshire required capture and translocation of Slow-worms to fulfil the legal obligations of 1981 Wildlife and Countryside Act (as amended). Numbers of adult males, adult females and juveniles were recorded. Only 3 of 577 Slow-worms captured were found moving or basking on the surface. On days with high capture rates, females and juveniles were more active. The disturbance pattern due to sampling, as well as human activity not related to translocation, affected capture rates. The settling-in period for refugia was not as important as believed. When translocating Slow-worms, it is important to ensure significant capture effort is made throughout the season rather than attempting to choose 'suitable' conditions. It is also important to ensure that the density of refugia placement is as high as possible.

ALTHOUGH frequently occurring close to human habitation, the Slow-worm is poorly understood due to its secretive behaviour, the difficulty of studying individuals over long periods and the subsequent lack of detailed study (Beebee & Griffiths, 2000). The species is widespread in the South and South East of England but there are indications of a decline during the second half of the 20th century (Baker *et al.,* 2004). Urban development has been identified as a particular threat with Slow-worms often found on brownfield sites targeted for redevelopment following recent changes in planning policy (Defra, 2003). As reptiles are protected from 'intentional' death and injury under the 1981 Wildlife and Countryside Act (as amended), it is necessary in some cases to translocate Slow-worms prior to development work. With consultation still taking place regarding the South East Plan (HCC, 2005), a regional UK Governmental plan for increases in housing levels, there is still uncertainty about the location and amount of redevelopment that will take place, and hence about the subsequent threat to Slow-worm habitat. It is clear that greater understanding of Slow-worm populations and the processes of capture and translocation is required.

Although attempts have been made to standardise reptile survey methods (Reading, 1996, Reading, 1997), there is no single accepted standard methodology for surveying reptile populations (RSPB *et al.,* 1994). UK Government body English Nature advise that the method used for translocation should be based on guidelines produced by the Herpetofauna Groups of Britain and Ireland (HGBI, 1998). More recent advice (JNCC, 2003) is also taken into account to meet the legal requirement of 'reasonable effort' to avoid death and injury to Slow-worms on site. Following an initial survey (CPM, 2005), it was determined from HGBI (1998) guidelines that a "good" breeding population of Slow-worms was present in the rear gardens of properties in Grange Road and Borough Grove, Petersfield, Hampshire. As the entire site is due for redevelopment, translocation was necessary. This was recognised as an opportunity to record Slow-worm numbers and relate these data to translocation methodology.

Translocation methodology

A suitable receptor site of approximately 10 hectares was identified at Goswell Brook in the Beaulieu Estate, New Forest, Hampshire, southern England (OS grid reference SU395044). The suitability of the site was determined to be high for the following reasons:

a. Being within Hampshire, it is relatively local to the Petersfield donor site, reducing the period of captivity and transit.

b. The site has undergone clearance of invasive *Rhododendron ponticum* and subsequent regeneration as heathland and acid grassland which are known to provide suitable reptile habitat (Wynne *et al.,* 1995; Haskins, 2000) and are within the natural range of the species.

c. Following discussion with the Goswell Brook conservation advisor regarding previous survey work, the receptor site was believed to support very few reptiles. This is because the site is still surrounded by *Rhododendron*, and so a significant level of Slow-worm colonisation has not previously occurred as individuals would need to migrate through considerable stretches of unfavourable habitat. As Slow-worms have a small home range averaging approximately 200m^2 with few moving more than 4m in a single day (Smith, 1990), colonisation from existing populations external to the site has not occurred.

d. It is not subject to planning or other threats in the foreseeable future.

e. There is little or no disturbance by humans.

f. Planned site management for nature conservation purposes will continue to maintain, enhance and expand the habitat suitable for Slow-worms, and future voluntary monitoring will determine the success of the translocation.

Translocation started on 14th July 2005. Broadly following the initial survey (CPM, 2005), 117 numbered artificial refugia (0.5m x 1m rectangles of roofing felt) were placed in areas of suitable habitat in the rear gardens of 36 properties. Slow-worms are well known to hide under debris which is fully or partially exposed to sunlight and artificial refugia provide a controllable method of using this behaviour to aid capture (JNCC, 2003). Refugia were placed in all 34 properties identified in the CPM survey plus 2 added after being observed to include suitable habitat. After a settling-in period of several days, a series of visits during July to September was undertaken, avoiding days considered too hot or wet. This gave a total of 48 worker-days of capture effort plus extra visits made to those gardens where the greatest proportion of the population appeared to be concentrated. Hand catching by lifting refugia was the main method used and, although the site covered approximately 2.5 ha, capture focused on smaller areas such as compost heaps where high numbers of individuals were expected, or ‘hotspots’ (defined as areas where Slow-worms were captured regularly, even when total capture for the day was low). This allowed sampling density to match that suggested by a key study of Slow-worms in southern Britain (Gent, 1994) which recommends 50 refugia per 0.1 ha with a minimum of 15–20 visits in order to capture a ‘reasonable’ proportion of the population. This targeting was amended throughout the work period as some areas became depleted and others began to produce greater numbers of individuals. Due to the gradual refocusing of capture effort, this study effectively reduced the area being sampled from 2.5 ha to approximately 0.1– 0.2 ha. Therefore, the 117 refugia represent a sampling density of up to 1170/ha.

Particular efforts were made to make as many visits as possible before the September birth period as this would repopulate depleted habitats with hatchlings which would then need to be captured. During the final visits, destructive searches were made where necessary. This allowed the primary aim of the the translocation (the capture and translocation of as large a proportion of the population as possible) to be met while also producing data suitable for analysis. The following data were recorded separately each day:

1. Total number of adult males, adult females and juveniles. As it is difficult to determine the sex of a Slow-worm before its third season (JNCC, 2003), all individuals too young to be sexed were recorded as juveniles. Plates 1 & 2 show the contrasting male and female patterns. The percentage contribution of each to the total number of individuals could then be calculated.
2. Number of days since the previous visit.
3. Number of gardens where individuals were captured.
4. Maximum temperature during daily capture effort.

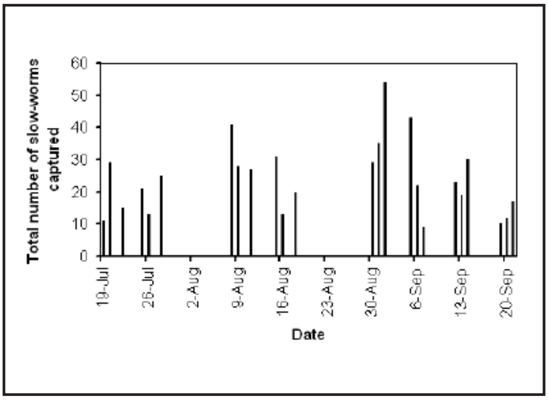

Figure 1. Number of Slow-worms captured during daily visits during 2005.

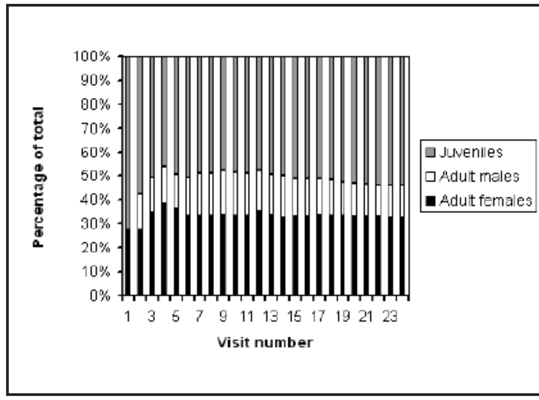

Figure 2. Proportion of Slow-worm captures by sex and age group.

RESULTS

A total of 577 individuals (186 adult females, 81 adult males and 310 juveniles) were captured. Of these only 3 were found moving or basking on the surface and 3 blue-spotted males were found. Figure 1 shows the pattern of capture with a peak around late August to early September. After this, a decline was seen, especially given that the last two visits included destructive searches which increased numbers slightly above those found by the standard methods of hand searching and checking refugia. Figure 2 shows a steady contribution to total captures by sex and age group with adult females forming 33.13% of total captures, adult males 15.12% and juveniles 51.75%.

Population ecology

Correlating the number of gardens where Slow-worms were captured with the total number captured gives a significance of $p < 0.001$. Correlating the number of gardens where Slow-worms were captured with the number captured by sex or age class gives $p < 0.001$ for adult males, adult females and juveniles. For each of these classes, correlating the overall total number of captures with total captures by group also gives $p < 0.001$. Hence increases are due equally to all classes rather than any section of the population. Total captures by sex and age class were correlated with mean number of captures per garden overall:

Adult females	$0.01 > p > 0.001$
Adult males	not significant
Juveniles	$p < 0.001$

Correlating the mean number captured per garden where individuals were found with the total number captured gives $p < 0.001$. There is no significant correlation between the mean number captured per garden where individuals were found and the total number captured. Correlating the total number of captures with the maximum temperature during each day of capture effort, shows a significant relationship ($0.01 > p > 0.001$). Correlating maximum daily temperature with age and sex classes shows a significant increase across the whole population:

Adult females	$0.05 > p > 0.01$
Adult males	$0.01 > p > 0.001$
Juveniles	$0.05 > p > 0.01$

Methodological effects

Correlating the mean of number of days since the last visit with the total number captured is not statistically significant. However, correlating the mean of the previous three periods against the total number captured is significant at $0.01 > p > 0.001$.

DISCUSSION

With 577 individuals captured, the size of population far exceeded that estimated in the initial survey (CPM, 2005). With a full range of age ranges from new hatchlings to large adults, a well-established breeding population was clearly present consisting of approximately equal number of adults and juveniles, with twice as many adult females found as adult males. This is likely to be a site-specific sex ratio as this is known to vary from previous studies (Stumpel, 1985; Smith, 1990). An excess of females has previously been explained in terms of gravid females basking in the open more frequently and being easier to catch (Stumpel, 1985), but in this case only 3 individuals were captured on the surface, so this explanation does not hold here. Recent work (Meek, 2005) indicates that above-ground activity has a thermoregulatory function, suggesting that the low numbers of basking animals is due to suitable temperatures being attained in sub-surface locations. Although the longevity of the species means that numbers of adults are usually much higher than numbers of juveniles (Beebee & Griffiths, 2000), some populations are not dominated by adults with one other key study finding a population in which around half the individuals were juveniles (Riddell, 1996). Suggestion has been made that gardens may provide consistently good conditions and thus lead to greater reproductive success and greater numbers of juveniles than more ‘natural’ habitats (Beebee & Griffiths, 2000). Alternatively, given the apparently high level of feline predation on site, the longevity of Slow-worms may be reduced here. This could at least partially account for the age structure if feline predation primarily affects adults and is sufficient to outweigh the usual predation of juveniles by insectivorous birds, frogs, toads and shrews, all of which are known to prey on small Slow-worms (Beebee & Griffiths, 2000).

The habitat is split into several isolated sections and as Slow-worms generally move short distances (Smith, 1990), these are likely to have partially separate sub-populations with some overlap due to movement of individuals. Along with the well-established nature of the population, this suggests a high level of genetic diversity which is important for successful translocation. As the primary aim of translocation is to capture as many Slow-worms as possible, it is important to consider the time of year when most Slow-worms will be encountered. Reading (1996) found the peak to be in mid to late September, Beebee & Griffiths (2000) indicate that this will be in May and June, while Figure 1 shows peak capture during late August and early September. Local and climatic conditions are likely to be of primary importance, but as it is impossible to determine what these will be in advance, it is essential to plan capture effort throughout the season.

In this study, higher temperatures led to greater numbers of captures although it is believed that hot dry weather leads to a reduction in Slow-worms’ use of surface refugia and that Slow-worms will not tolerate termeratures above 35°C (Beebee & Griffiths, 2000). This is explained by the hottest periods being avoided during translocation so that capture effort occurred only during suitable conditions. When refugia were checked during hotter periods, very few Slow-worms were found. Reading (1996) also found that the capture rate increased with density of refugia placement with no noticeable tail-off at higher densities. This can be explained by the sedentary nature of Slow-worms as an individual may stay in a very small area (possibly a single compost heap or ant nest of 1–2 m^2) for a considerable period of time if food supply and cover remain adequate. Thus a very high density of refugia would be required before the number of captures began to tail off. Reading

Plate 1. Adult male during release at receptor site.

Plate 2. Adult female during release at receptor site.

(1996) suggests this would occur above approximately 3200 refugia/ha, and used a maximum density of 379 refugia/ha which the author notes was not enough for the number of captures to level off. Here a sampling density of up to 1170/ha was used. Thus key considerations when translocating Slow-worms are:

1. To make significant capture effort throughout the season rather than attempting to choose suitable conditions.
2. To place refugia as densely as realistically possible. Given that the species moves only short distances daily (Smith, 1990), refugia need to be placed in close proximity to the Slow-worms rather than assuming that Slow-worms will disperse to the refugia.

Undertaking sufficient capture effort is all the more important given that in many cases it is impossible to determine Slow-worm population size from initial surveys due to both the difficulty of individual recognition (Baker *et al.,* 2004) and the species' fossorial lifestyle (Platenberg, 1999). Increases in total capture rate are due to individuals being found across a greater proportion of the site, rather than increased density of capture per garden. On days with fewer captures, those found were mostly in the key 'hotspots'. Increases are therefore due to Slow-worms being found over a larger area, rather than higher densities being found in key areas.

The period between single pairs of visits does not have an effect on capture success (e.g. in terms of disturbance or having depleted numbers locally by the previous visit's captures), but increased disturbance does have an effect over longer periods. With an average of three visits per week, individual disturbance events (i.e. shorter periods between pairs of visits) do not reduce capture success, but a series of closely-spaced visits within one week does reduce capture success. As refugia density was reduced in areas where captures had fallen to zero, and refugia moved to areas of high capture rate, it can not be clearly determined whether disturbance or depletion of numbers is the reason for this result. However, if the number of visits is limited, the result suggests that it is better to spread them evenly. There is no evidence that leaving longer gaps and thus introducing periods of low/zero disturbance increases the number found. Conversely, when refugia were moved or suffered unplanned disturbance, Slow-worms were very often found beneath them the next day, whereas if an entire garden was disturbed (e.g. by grass-cutting), Slow-worms were not found there for some weeks if at all, even once vegetation had regrown. This suggests that the usual 'settling in' period for refugia (often considered to be around 10 days) may not be essential, but that if Slow-worms suffer enough disturbance to move away from one location, their sedentary behaviour means that the recolonisation period may be considerable.

Increases in capture density were due to increased capture of juveniles and adult females, but not adult males. This implies that adult females and juveniles can become more active with adult males level of activity remaining the same. Given the correlation with maximum daily temperature, this indicates that factors other than temperature were important in determining activity levels. A number of reasons for the difference between male and female-juvenile activity are suggested:

1. Adult males populate the best areas of habitat and have no need to move. It is already known that males emerge from hibernation before females.
2. Adult females may use these periods to move to locations relating to reproductive activity such as courtship, mating and birth.
3. Juveniles may use these periods to seek new home ranges, although these may overlap considerably as Slow-worms are not territorial.

Following the end of translocation work in 2005, areas of suitable habitat were managed in order to concentrate any remaining Slow-worms in small areas such as grass piles, compost heaps and dense piles of other debris. Along with the removal of any loose household debris, this requires the cutting of grass around these areas, with cuttings being collected and either disposed of or used as habitat piles as appropriate following consulatation with an experienced ecologist. This concentrates the remaining population in a smaller overall area, renders densely vegetated areas accessible for searching, and facilitates future capture. Phase 2 of translocation work began in March 2006 and is planned to continue until September 2006 to ensure that the requirements of a full season and sufficient number of visits has been met according to HGBI guidelines (1998). This will also prevent recolonisation between the end of the survey and the start of the second phase of development in late 2006. A survey is planned which will assess the success of translocation.

Evaluation

The data gathered during this study helps to explain the effects of sampling strategy on capture success and provides some information about the aspects of population dynamics relevant to Slow-worm capture and translocation. It is important to note that data gathering was a secondary aspect of a translocation programme undertaken as consultancy work. Therefore, although this work was undertaken with data gathering in mind, its primary aim was to capture as many Slow-worms as possible during the alloted visits. Gardens without Slow-worms were removed from the programme while areas with abundant populations were sampled more intensively. Along with differences in accessibility between gardens, this means that capture effort was not evenly distributed across the site in terms of either density of refugia placement or number of visits. However, care was taken to collect data in as consistent and thorough a manner as possible given these constraints.

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