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An Evaluation of the Effectiveness of Footprint Tracking Tunnels for Detecting Hazel Dormice

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Hazel dormouse.

Traditional survey techniques for hazel dormice include nest tubes and nest boxes or detection of field signs. We present details of the use of footprint tunnels as a non-invasive tool for detecting their presence and demonstrate that the technique, when compared with other methods, is a more effective survey tool within scrub and hedgerow habitats. In high canopy woodland, footprint tunnels perform at least as well as traditional techniques. We provide recommendations on survey protocols and encourage ecologists and site managers to consider using footprint tunnels when undertaking surveys.

Introduction

The hazel dormouse *Muscardinus avellanarius* is native to England and Wales and is a scarce, arboreal small mammal

of woodlands, hedgerows and scrub, hibernating at ground level in winter. They are a 'European Protected Species' under the EU Habitats Directive (1992) enacted as the Conservation of Habitats and Species Regulations (2017) within the dormouse range in the UK. Although currently described as of 'least concern' in the IUCN Red List, an analysis of data derived from the UK's National Dormouse Monitoring Programme (NDMP) indicates that they have suffered a 72% population reduction in the last 22 years (Goodwin *et al*. 2017) and a recent review describes them as 'vulnerable' within their UK range (Matthews *et al*. 2018). Consequently, knowing where dormice occur is an essential first step towards securing a sustainable future for populations which, if undetected, would be vulnerable to habitat loss and fragmentation arising from development.

Methods of detection of hazel dormice currently fall into two categories: searching for field signs (gnawed hazel nuts and summer nests), or the more frequently used techniques of deploying nest tubes and/or boxes in woody vegetation within which the animal may build a nest during its active phase.

Despite a range of methods being available, hazel dormice can be a difficult species to detect. In the absence of fruiting hazel *Corylus avellana* or a dense shrub or scrub layer, field signs cannot be found. Similarly, in habitats such as unmanaged mature woodland or over-stood coppice, there may be plentiful tree crevices high in the branches and dormice may be less likely to nest in boxes or nest tubes. Likewise, when there is a poorly developed shrub layer there may also be a reduced incentive for dormice to venture lower to the ground, potentially resulting in a false negative for a nest tube or nest box survey.

Dormouse footprint detection

Hazel dormice have very distinctive triangular-shaped pads on the 'palms' of both their front and hind feet (Figure 1, Box 1).

Several studies have already been undertaken to investigate the potential for dormouse footprint detection, using a variety of devices. These include modified bird feeders (Mills *et al*. 2016), Tetra Pak

Figure 1. Close-up of hazel dormouse hind foot showing triangular palm pads.

Box 1. Recognising dormouse footprints

When a dormouse footprint is left behind on white card, it is usual to see three obvious triangles, although this is dependent upon the quality of the print (Figure 2). In addition, both feet are usually turned outwards when walking on a flat surface, so the toe prints (if present) appear offset to the direction of travel. The fifth toe on the hind foot rarely prints and the three central toes of the hind foot are arranged close together. Wood mice *Apodemus sylvaticus* and yellow-necked mice *A. flavicollis* are also highly arboreal and regularly enter footprint tunnels but compared with dormice their palm-pad prints appear more rounded (Figure 3). It is difficult to reliably separate the two *Apodemus* species based on their footprints.

Figure 2. Hazel dormouse footprints. Front foot (blue) and hind foot (red).

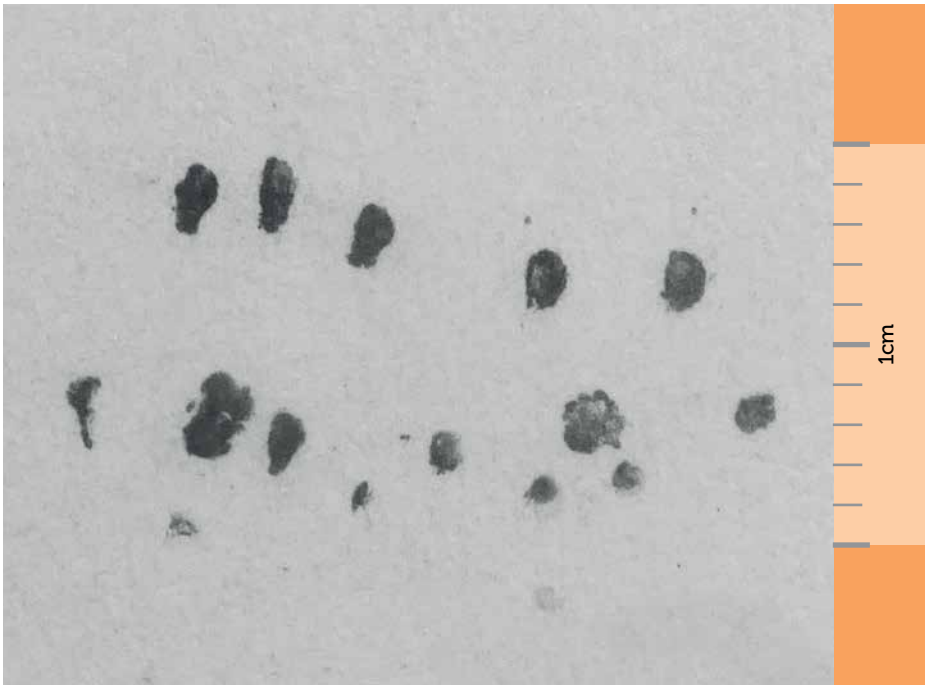

Figure 3. Wood mouse footprints. Hind foot (left) and front foot (right).

cartons (Haag and Tester 2016), modified nest tubes and sections of plastic down-pipe (Middleton-Burke 2017). Where bait was used, it was necessary to protect the tracking device from grey squirrel *Sciurus carolinensis* damage. All these studies found that it was possible to obtain hazel dormice footprints and that they were distinctive from other small mammal footprints.

Evaluating the effectiveness of footprint tunnels

In 2017, we tested how well footprint tunnels detected hazel dormice, compared with other survey methods. We used a simple, low-cost design constructed from black plastic down-pipe with a wooden insert (Figure 4, Box 2). In 2016, we successfully trialled this equipment and

Box 2. Footprint Tunnel Design
(see Figure 4)

The footprint tunnels are constructed out of 65 mm square black drainpipe cut to 400 mm lengths, with plywood cut to 500 mm lengths to provide a landing platform on either side of the tunnel. As no significant difference in detection occurred whether the tunnel was fixed on top or beneath a branch, the tunnels are best attached using two black cable ties (4.7 mm x 380 mm) to the underside of horizontal branches as they are more stable in this position.

In the centre of the plywood is a strip of high quality white card (250 gsm/350 microns) cut from an A4 sheet along the long edge and attached to the plywood using double sided sticky tape. Masking tape is wrapped around the ply at either end of the card but not overlapping it, to enable the card to be easily removed and replaced. The tracking medium is painted onto the masking tape in a thin layer. It is a mixture of three heaped teaspoons of ultra-fine, pharmaceutical grade activated charcoal powder (considered to be safe for dormice) to 15 level teaspoons of olive oil, which provides sufficient quantity for approximately 50 footprint tunnels. The consistency is similar to tomato soup! No bait is used. The unit cost is around £2 each, excluding consumables.

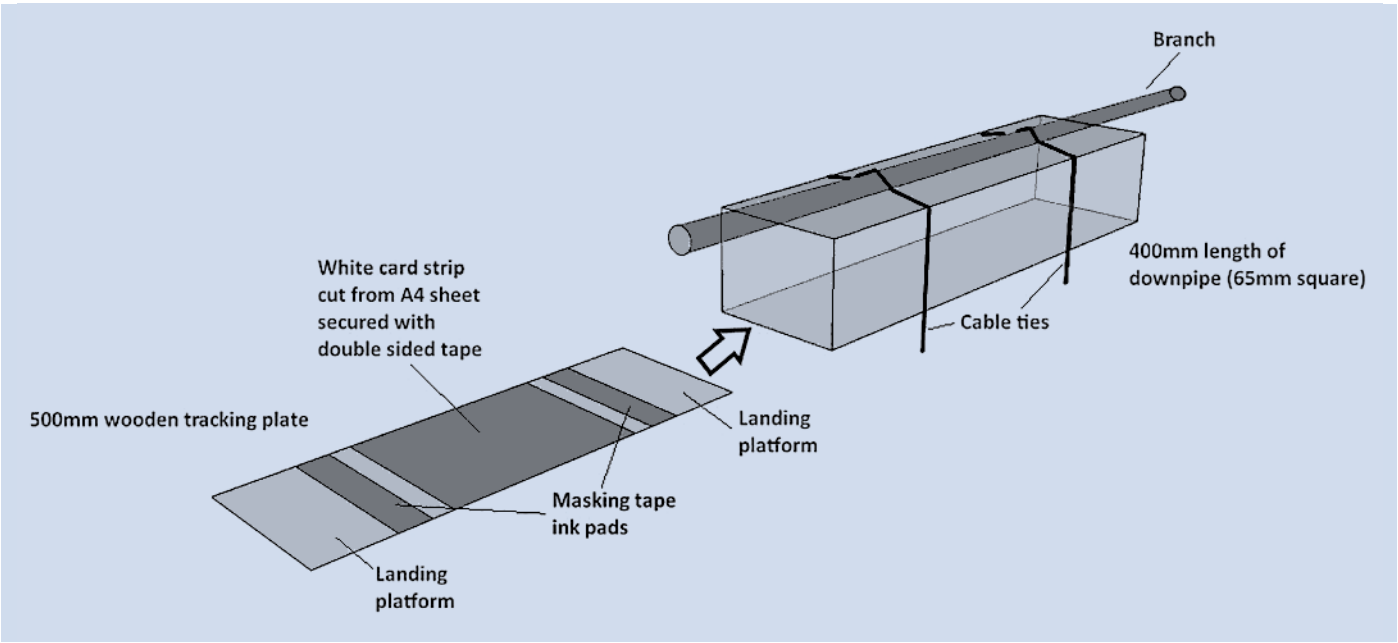

Figure 4. Footprint tunnel design showing the arrangement of card and ink pads on the wooden tracking plate, which is inserted into the shorter tunnel made of square downpipe.

found that dormice would readily enter the tunnel without any added attractants, so no bait was used.

Twelve sites in south Suffolk with varying habitats were chosen for the study. These were already part of the National Dormouse Monitoring Programme (NDMP) or were sites where previous surveys had revealed dormice were present. Fifty sampling points, 15-20 metres apart, were set up at each site in either a grid in woodlands or in a transect for hedgerows and scrub sites. At each sampling point a dormouse nest box, nest tube and a footprint tunnel were placed in woody vegetation, approximately within one metre of each other and at 1-1.5 metres height, depending on the habitat. At each site, random number tables were used to place half of the tunnels above the branch and the other half below, but it was subsequently found that tunnel position had no significant effect on levels of dormouse detection.

The nest boxes and nest tubes were checked at the end of every month from April to November 2017 and nests and animals were recorded where present. The footprint tunnels were checked twice every month as it was necessary to renew the ink after two weeks, but any footprints in a tunnel were only recorded once, even if present in both checks. Card was replaced whenever footprints of any species were present, or if found wet or damaged by molluscs. In addition, searches for natural nests and nibbled hazel nuts were carried out in the autumn.

By the end of November, hazel dormice had been detected at ten sites, with nest boxes, nest tubes and footprint tunnels all confirming presence. Natural nests were also found at all the positive sites but opened hazel nuts were found at only five sites. At the two negative sites, dormouse presence was already known to be very low from surveys in 2016.

Survey results

The overall detection rates (i.e. the proportion of deployments where presence was detected in a month) between the three methods were compared, with formal statistical comparison based on a binomial Generalised Linear Mixed Model (GLMM). The analysis took into account the non-independence of the data which arose from having a nest tube, nest box and footprint tunnel at the same sampling points. Figure 5 compares the presence of nests in the three different habitats against the presence of footprints. The 'box or tube' bar refers to the proportion of times where detection occurred in the box or the tube, indicated by the presence of a nest (old or new) or a dormouse. As adjacent nests appear to elevate adjacent footprint levels, in the analysis all tunnels were excluded where situated adjacent to a box or tube where dormice were ever recorded.

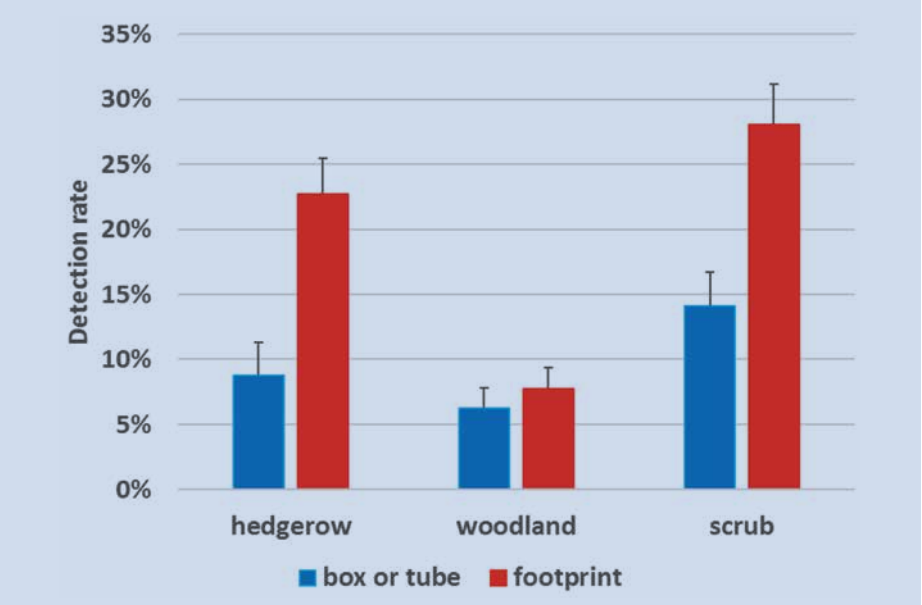

Figure 5. Comparison between hazel dormouse detection rates using either nest boxes or nest tubes and using footprint tunnels in three different habitat types. Bars are upper 95% confidence limits. Data were collected over an 8-month period and represent 868 detection events.

We found that footprint tunnels are considerably more effective at detecting dormice in hedgerows (22.7%, 95% confidence limits +/- 2.7%) and scrub (28.1% +/- 3.1%), when compared with nest detection in these habitats (8.8% +/- 1.6% for hedgerows and 14.1% +/- 2.0% for scrub). The lowest detection rates occurred for the three closed-canopy woodlands, with no significant difference in detection rate between the two survey types.

The differences in the detection rates between months also varied, with highest detection rates between May-October, and with the lowest in April and November. Further analysis of our data revealed that if 50 footprint tunnels are deployed for three months between May to October, the probability of detecting dormice, even where they are likely to occur at very low density, is 97.5%. Compared with nest tube surveys, this has considerable value in reducing the survey period and providing an earlier indication of the presence or likely absence of dormice in a development context.

Implications for professional practice

Footprint tunnels provide greater certainty of detection of hazel dormice in hedgerow and scrub habitats and are more likely to achieve positive results within a shorter timescale, when compared with nest tubes and nest boxes. This is not surprising as it only takes a fleeting moment at the entrance of a tunnel for the evidence to be obtained, compared with the amount of activity associated with nest-construction.

The cost of the materials compares well with nest tubes, although the twice-monthly checks to re-ink the pads and change the papers requires increased surveyor time. The tunnels are heavier and bulkier than nest tubes and if access to the survey location is only by foot, then fewer can be carried by a surveyor at any time. In our pilot study, we attempted to reduce the size of the tunnel but found this was detrimental to keeping the tracking paper dry. However, these minor negative

Figure 6. Footprint tunnel *in situ* within a hedgerow.

points are offset by the benefits of an early indication of dormouse presence. In addition, a footprint tunnel survey started at the beginning of August, following the recommended methodology until the end of October, would demonstrate a high probability of likely absence in the event of a negative survey.

The method does not require a survey licence, although there is a slight risk that a dormouse could be encountered. During the study, dormice were encountered on four occasions in footprint tunnels, two where a nest had been constructed that disappeared by the following month and two other occasions when a dormouse was seen leaving a tunnel. This represents four encounters out of 9,600 possible occasions, so the likelihood of a surveyor encountering a dormouse during a footprint tunnel survey is considered to be low. However, the survey should always be halted in the event of a non-licensed surveyor coming across a nest or an animal in a tunnel. Footprint tunnels are also an ideal survey method in areas of high public disturbance because should the tunnel be investigated, a dormouse is highly unlikely to be present. In contrast, they are more likely to be present within a nest tube or nest box during the day and consequently are more vulnerable.

It is advisable for a surveyor to have some knowledge of hazel dormouse habitat requirements and ecology in order to set out the footprint tunnels in a way that is most likely to detect them. For this reason, we recommend that surveyors should either hold an existing dormouse survey licence or, at the very least, have been trained in the technique. Dormice footprints can be very faint and hard to spot, particularly when in amongst numerous other small mammal or bird prints. Consequently, we recommend that papers are collected and labelled in the field so they can be carefully checked later and independently verified if required.

When setting out footprint tunnels, these should be placed beneath horizontal branches and secured using cable ties (Figure 6). When used in combination with nest tubes, they can be placed at the same locations or alternating with each other, as long as the spacing between nest tubes remains at 15-20 m. The height that the tunnels are secured will depend upon the habitat type, but they are most effective when placed in dense woody vegetation at least a metre above the ground.

Wherever possible, the tunnels should be aligned along a transect. In woodlands, we recommend that woodland edge habitat or ride edges are chosen, rather than placing the tunnels in a grid. This is because dormice are more likely to forage within edge habitat where sunlight will promote flowering and fruiting of shrub species. In scrub, the tunnels should again be placed to maximise edge habitats which will be the most productive as food sources. As such habitats are often thorny, it can be a challenge to place and check the tunnels, but we have found that these locations are very good for detecting dormice. Bramble entanglements are also useful detection sites, but several bramble stems may be required to secure the weight of the tunnel. In hedgerows, consideration should be given to whether they will be flailed in the autumn and that the placing of the tunnels is deep enough within the hedge to remain unaffected.

Footprint tunnels are currently only used as a presence/likely absence technique and therefore in built-development scenarios this survey technique alone cannot provide

the level of detail required to fully evaluate any impacts. It is therefore essential that they are used in conjunction with other validated methods for projects that may result in a dormouse mitigation licence being required.

Regardless of the above, the outcomes of our study confirm that footprint tunnels are a viable, non-invasive survey method for detecting hazel dormice and should now be given serious consideration as an effective survey technique.

Recommendations for footprint tunnel surveys

1. A footprint tunnel survey should be undertaken for at least three months in the period May to October, unless dormouse evidence is detected. However, in the absence of any footprints or any other survey evidence such as nests in habitats where dormouse presence is thought likely, the survey should be continued beyond three months.
2. A footprint tunnel survey must be used in combination with another detection method such as nest tubes and nest boxes if the survey is for built-development purposes or is likely to require a mitigation licence.
3. If it is suspected that the survey location is not permanently occupied by dormice but is used primarily as a dispersal corridor, the months of September and October should be included in the survey.
4. Although footprint tunnels can be put out from late March, if no dormouse evidence is recorded in April then this month should be excluded from the three-month survey duration due to low detection rates at this time of year.
5. As dormice footprints can be hard to spot, all papers should be collected and labelled in the field, so they can be carefully checked later and independently verified if required.

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