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Original Investigation

Hair tubes for estimating site occupancy and activity-density of *Sorex minutus*

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ABSTRACT

Hair tubes are efficient for sampling shrews and potentially important for sampling *Sorex minutus*, which is poorly sampled with other methods such as live trapping. We tested the effect of aperture size, bait, and position and type of sticky strip in hair tubes on the detection of *S. minutus* hairs. The optimum *S. minutus* hair tube design has high specificity for *S. minutus* (hairs are 12 times more likely to be from *S. minutus* than from other species), easily constructed and suitable for use in large-scale surveys. Between the end of July and middle of September 2008 we repeatedly surveyed 46 sites twice with a transect of 20 *S. minutus* hair tubes. Occupancy of *S. minutus* was higher in hedgerow sites (0.92) than grassland (0.59) and woodland sites (0.42). Relative activity-density was estimated from models allowing abundance-induced heterogeneity in detection probability and was also higher in hedgerow sites (1.75) than grassland (1.23) and woodland sites (0.72). Relative activity-density is a function of abundance and movement and hence should be interpreted with caution but is a valuable parameter to estimate from data on presence or absence of a species at a site. From our data we recommend that surveys are carried before the end of August, in which case three surveys per site at up to 120 sites per habitat (depending on habitat and start date) are necessary to obtain precise estimates of site occupancy. Site occupancy should be quantified as a relevant parameter alongside abundance when conducting indirect surveys of mammals and relative activity-density should also be considered.

Introduction

Mammals are ecologically important as prey and predators in food webs, as ecosystem engineers and as potential biotic indicators of habitat change (Pocock and Jennings 2007). However, monitoring populations of mammals is challenging, certainly more challenging than monitoring birds (Battersby and Greenwood 2004). This is because most European mammals are cryptic, nocturnal and/or small, making them difficult to detect. This is particularly true for small mammals, i.e. shrews, mice and small voles, and as a consequence large-scale population trends of small mammals are poorly known (e.g. Battersby 2005).

Live trapping is frequently used to survey small mammals (Gurnell and Flowerdew 2006). Live trapping can provide high quality data to estimate abundance, population age structure and movement (Flowerdew et al. 2004), but its use is limited by cost, both in time and money. Live trapping has a particular disadvantage for sampling *Sorex minutus* (the pygmy shrew) because such a light species (3 g) may not trigger the trap, even a Longworth trap for which the sensitivity of the trap can be altered (Gurnell and Flowerdew 2006). Large-scale monitoring schemes are under development in the UK (Harris and Yalden 2004; Battersby 2005), for which effective and efficient methods for surveying all mammals are essential.

Hair tubes are effective for sampling *S. minutus* (Pocock and Jennings 2006) and therefore provide a method for indirectly surveying for the presence of *S. minutus*. Hair tubes have, bisecting their aperture, a sticky strip to which hairs from individuals that enter stick. Shrew hairs can be classified to species by the analysis of measurements from binocular microscopy. In tubes with small apertures, most hairs are identified as *S. minutus* (Pocock and Jennings 2006), so it may be possible to develop a hair tube which is selective for *S. minutus*: a valuable species-specific sampling method for monitoring schemes (Harris and Yalden 2004).

Indices of relative abundance derived from hair tubes on transects, e.g. number of tubes positive for *S. minutus*, can be compared between sites, assuming that detection probability is similar between sites. This assumption was tested by Pocock and Jennings (2006), but is unlikely to hold in all seasons and habitats (Slade and Blair 2000; White 2005). Instead of abundance, population parameters that can be estimated more robustly should be used for indirect surveys: for instance, site occupancy provides information about range size, habitat preferences, and their changes over time and space (MacKenzie et al. 2005) and can be used for monitoring (Royle et al. 2005). The probability of site occupancy can be estimated from

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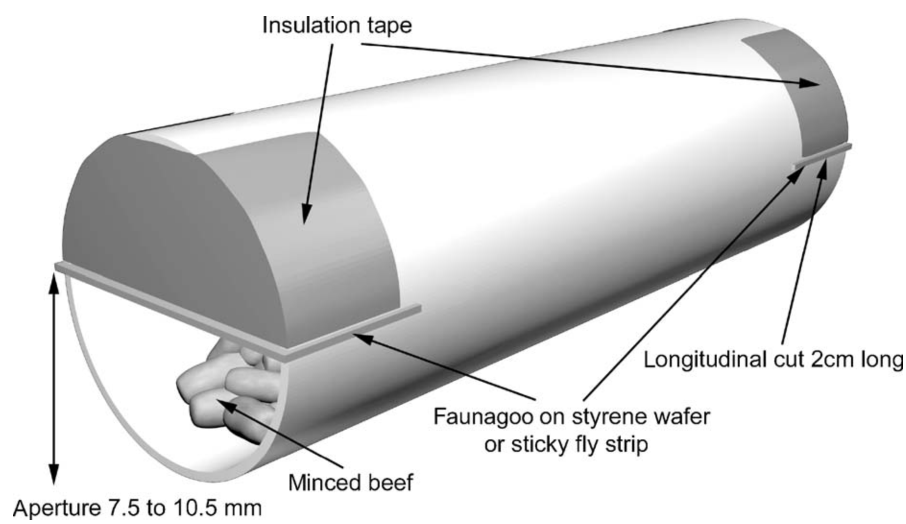

Fig. 1. Optimum design of the hair tube for surveying *Sorex minutus*. The sticky strips are inserted into longitudinal cuts in the tube and bisect the aperture to give an aperture size of between 7.5 and 10.5 mm.

repeated surveys of sites at less cost than estimating abundance at each site (Royle and Nichols 2003; MacKenzie et al. 2005).

Site occupancy and its probability of detection vary due to covariates of interest to surveyors (e.g. habitat type, altitude, and latitude) and this variation can be modelled and estimated (MacKenzie et al. 2002). Variation in detection probability can also be modelled and may be of interest because it is related to variation in abundance (Royle et al. 2005). This abundance-induced heterogeneity in detectability can be modelled from repeated surveys and presence–absence data, so mean abundance (λ) can be estimated (Royle and Nichols 2003). The interpretation of λ as abundance requires caution, especially from surveys of signs (Stanley and Royle 2005). Here, we use λ to mean activity-density, a function of abundance and movement (Thomas et al. 2006).

Our aims in this study were: to develop a species-specific method to sample *S. minutus*, suitable for large-scale surveys; to use our method for a large-scale survey to estimate habitat-specific site occupancy by *S. minutus*; and to make recommendations for optimal survey design.

Material and methods

Hair tubes

Pocock and Jennings (2006) developed a set of three hair tubes with varying aperture used by all three species of shrew present on mainland Britain (namely *S. minutus*, *S. araneus* and *N. fodiens*). Most hairs in the smallest tube (10.5 mm aperture size) were identified as belonging to *S. minutus*. We therefore tested the effect of aperture size on the selectivity of tubes for *S. minutus*, to determine which aperture size was small enough to be as species-specific as possible, but large enough to have as high a capture rate for *S. minutus* hairs as possible. We surveyed during summer when shrew numbers are at their highest.

Hair tubes were constructed from 10 cm lengths of round plastic electrical conduit (21 mm diameter, white in colour to aid their relocation in the field). The aperture at both ends was bisected by sticky strips inserted into longitudinal cuts in the tube. By changing the position of these cuts we altered the size of the aperture for entry by shrews. Electrical insulation tape was placed across the top half of each aperture to allow entry only under the sticky strip (Fig. 1).

We first tested the effect of the (1) size of aperture: 12.0, 10.5, 9.0 and 7.5 mm, (2) the presence or absence of blowfly (*Calliphora* sp.) pupae as bait, (3) the position of the sticky strips: at the end of the tube or in the middle of the tube, and (4) the type of sticky strip: Faunagoo (Faunatech, Australia) or fly traps ('Yellow Sticky Traps', AgriSense, Pontypridd, UK). We set tubes in 5–9 subsites in each of 12 sites (118 locations in total) in south west England, within 80 km of Bristol. Sites were separated by >5 km and subsites by >150 m. At each subsite we placed four tubes (one of each aperture size) on the ground and under vegetation at the margin of a hedge, a habitat used by *S. minutus* and *S. araneus*. We used a balanced randomised design to assign treatments (bait, position and type of strip) to tubes. Tubes were placed between 9 June and 1 July 2008 for one week. An initial examination showed that the presence of bait had a very strong positive effect, so all tubes in the second half of this first trial were baited with fly pupae.

In a second trial we tested the effect of the type of bait. In 21 subsites, we laid transects of four tubes separated by 5 m. The tubes were alternately baited with about 6 blowfly pupae or 0.7 g of minced beef. All tubes had Faunagoo strips at both ends, and, within each location, had the same aperture (but due to the limited availability of tubes, sizes randomly varied between locations). Tubes were placed between 15 and 17 July 2009 for one week.

After collection, the strips were examined under a binocular dissecting microscope (MZS0745 L-R; GT Vision, Suffolk, UK) at 90× magnification. From each strip, one randomly selected guard hair was identified to species from four measurements (Pocock and Jennings 2006). Selecting numerous hairs per strip would have increased the probability of false positives, but where more than one guard hair was present on a strip, a second hair was identified to increase our confidence in the identification. Each strip could therefore be positive for only one species, but two species could be detected from each tube (one from each strip).

Analysis was carried out separately for the two trials with a multilevel logistic model (general linear mixed model) using the package 'arm' (Gelman et al. 2009) in R 2.10 (R Development Team 2009). The presence/absence of *S. minutus* hairs was the dependent variable. Presence of bait, position of strip and type of strip were fixed effects in both analyses. Aperture size was included as a fixed effect in the first trial and as a random effect in the second trial. Location within site was included as a random effect for both trails.

Estimating habitat-specific site occupancy

To estimate the probability of detection of site occupancy, so that we could make recommendations for optimal survey design,