**Surveying small mammals in urban hedges**

**Eleanor R. Atkins1, Ruth D. Swetnam1, Paul Mitchell1 and John W. Dover1**

ABSTRACT

The suitability of hedges and non-hedge linear boundaries for small mammals in urban Stoke-on-Trent were assessed in 2015 and 2016 using baited hair tubes and footprint tubes. Small mammals were found in 63% of all study hedges and 10% of non-hedge linear boundaries, with the upper levels of hedges used as frequently as the base. Hawthorn and privet hedges showed significantly more signs of small mammals than beech hedges or non-hedge linear boundaries. Our findings suggest that we should protect and enhance our urban hedgerow resource as a valuable habitat for urban small mammals.

1 Science Centre, Staffordshire University, Leek Road, Stoke-on-Trent ST4 2DF

Corresponding author: eleanor.atkins@research.staffs.ac.uk

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INTRODUCTION

Hedges are managed rows of trees or shrubs (Baudry et al. 2000) which support rural biodiversity (e.g. Forman & Baudry 1984, Dover & Sparks 2000, Groot et al. 2010) and it is well known that mammals use rural hedges (Sutton 1992, Benton et al 2003, Michel et al 2006, Gelling et al 2007, Staley et al. 2016). Although associated with the UK countryside, hedges occur within urban areas – either as relicts from previous land use or subsequently planted. Most hedges within the Midlands of the UK are composed of hawthorn (*Crataegus monogyna*) (Baudry et al. 2000), but beech (*Fagus sylvatica*) and privet (*Ligustrum ovalifolium*) are more likely to be found in urban environments (Gosling et al. 2016). Little is known about urban hedges in terms of their species composition, distribution, or value to wildlife and consequently we are ill-informed to protect, preserve, expand or future-proof this green commodity (Anonymous 2007).

The study was conducted in Stoke-on-Trent and the adjoining town of Newcastle-under-Lyme in the north Midlands of England. This city region has a combined population of 381,693 (Anonymous 2017) making it the 11th largest conurbation in the UK. Study hedges were located throughout the study area in both urban centres and residential areas.

Our aim was to carry out a survey of urban hedges to see whether they provide suitable habitat formice, voles and shrews, and whether this was affected by the main hedgerow plant species. Baker et al. (2003) found mammal traps within public areas were frequently moved or stolen. Since our study hedges were located in areas with high footfall, live trapping was not an option and simple presence/absence survey methods (Mills et al. 2016), robust enough to cope with busy urban environments, were used. Most mammal surveys are conducted at ground level but many small mammal species are known to be arboreal (Bright 1998, Juðkaitis, 1999, Buesching et al. 2008); thus we also investigated small mammal arboreality within the study hedges. The National Biodiversity Gateway was interrogated in a 5 km radius from postcode ST4 2DE, the centre of the study area, to see which small mammal species were likely to be present. The following rodent and shrew species were found: wood mouse, *Apodemus sylvaticus* (155 records), harvest mouse, *Micromys minutus* (3), field vole *Microtus agrestis* (16), house mouse *Mus musculus* (1), bank vole *Myodes glareolus* (9), brown rat *Rattus norvegicus* (90), black rat *R. rattus*. grey squirrel *Sciurus carolinensis* (908), water shrew *Neomys fodiens* (3), common shrew *Sorex araneus* (20) and pygmy shrew *S. minutus* (10). There were also records for: hedgehog *Erinaceus europaeus* (320); stoat *Mustela erminea* (17), weasel *M. nivalis* (24) and fox *Vulpes vulpes* (565).

METHODS

Site Selection

An inventory of hedges within the study area was compiled through walking and driving tours. To be included in the study, we decided that study hedges had to be a minimum of 30 m in length, at least 1.2 m high, at least 95% continuous (i.e. with minimal gaps), composed of at least 95% woody species and adjacent to an urban land use on one side (such as a road, car park, track).

‘Non-hedge linear boundaries’ (NHL boundaries), were also surveyed for comparison. These occurred, for example, where a hedge had been replaced by a fence, or on the opposite side of the road to a study hedge where no hedge was present. NHL boundaries were located as close as possible to the study hedges, but no more than 150 m away. Similar land use was present behind NHL boundaries and hedges. Thirty single species hedges (n=30), ten each of beech, hawthorn and privet, and ten NHL boundaries were selected. Map locations and example images of study hedges and NHL boundaries are given in the Supplementary Information.

Small mammal surveys

The hedges and NHL boundaries were surveyed for the presence of mammals during September and October 2015 and 2016. Two methods were employed: hair tubes in 2015 and footprint tubes in 2016 (see Supplementary Information for images of hair tube and footprint tube design). Overall, 450 hair tubes and 270 footprint tubes were placed within 30 hedges, and 50 hair tubes and 30 footprint tubes were placed within NHL boundaries.

Hair tubes (40 mm diameter x 150 mm) were baited with one level 5 ml spoonful of fly pupae and one heaped 5 ml spoonful of wild-bird seed. A fold of forensic lifting tape (sticky side out) was secured inside the tubes with double-sided sticky tape to hang low enough into the tube to brush against the back of a shrew entering or exiting the tube. The flexibility of the tape meant that it did not pose a barrier to mice or voles. Two sizes of footprint tube were used to collect footprints (65 mm x 65 mm x 250 mm, and 200 mm x 195 mm x 800 mm – large enough for mice, voles, and shrews but not larger species). Paint pads were constructed by painting masking tape with a mixture of non-toxic powder paint and sunflower oil. Two sheets of tracing paper to record footprints were positioned in the larger tubes and one in each of the smaller tubes. During pilot studies, tracing paper was found to be less palatable to slugs and snails, and the ability to overlay this on example footprints made identification more accurate. Cut-up hotdogs were put into an open Petri dish in the larger tubes to attract hedgehogs, but the smaller tubes were not baited.

Hair tubes were positioned at 5 metres (m) apart (horizontally) and 5 m in from the ends of the 30 m survey lines at three heights: at ground level, and at one third and at two thirds of the hedge height (Figure 1). Footprint tubes were placed 7.5 m from the ends of the survey lines and 7.5 m apart. Large tubes were placed at ground level and smaller tubes at one third and at two thirds of the hedge height along a branch, secured in place using cable ties. All tubes remained in the hedges for four nights and were visited at the end of this period, after which they were removed.

Figure 1: Positioning strategy for tubes within hedge. (a) Hair tubes positioned 5 m from end of 30 m section and 5 m apart at three heights– along the base, 1/3 of the way up and 1/3 from the top, (b) Footprint tube positioned 7.5 m from the end and 7.5 m apart at the same three heights.



Once collected, hair tubes were examined for droppings and other evidence such as caches or nesting materials to indicate use by small mammals. The tapes were removed from the hair tubes and examined for hair; if present, tapes were sealed in Petri dishes and labelled. Attempts were made to ID hair to species level using methods suggested by Teerink (1991) but with limited success. Sheets from the footprint tubes were collected and footprints identified.

Statistical analysis

Data were non-normal and non-parametric Kruskal-Wallis tests were used to compare the frequency of small mammal signs between types of hedge and NHL boundaries at ground level. Where significant differences were found, pairwise comparisons were made using Dunn-Bonferoni (Dunn 1964, Napierala 2012) post hoc tests. For the three species of hedge, which had tubes at different levels (ground level plus two heights above ground within each hedge), Scheirer-Ray-Hare tests (Ennos 2012) were used to identify differences between height, hedge species, and interactions between the two. Where significant differences were identified, Dunn-Bonferoni tests were used to identify where these differences lay. Prints of all mammals and prints of mammal species small enough to fit into the smaller footprint tubes (mice, voles and shrews) were compared separately.

RESULTS

Footprint tubes

Signs of mice/voles, shrews, cats, dogs, rats and squirrels were found in footprint tubes (Table 1); 63% of all hedges surveyed showed evidence of mice/vole or shrew activity compared with just 10% of NHL boundaries.

Of interest is that rat prints were not evenly distributed with hedge type (H=14.061, p= 0.002, n=40); they were found significantly more frequently in NHL boundaries than in privet (T=3.026, p= 0.015) or hawthorn hedges (T=3.026, p= 0.015), although overall numbers were low.

The number of larger footprint tubes with prints did not vary significantly (H=5.501, p=0.139, n=40) with hedge species/NHL boundaries. However, when we compared data for mice, vole and shrew prints the distributionswere significantly different (H=10.201, p=0.017, n=40). Prints were more likely to be found in hawthorn hedges than NHL boundaries (T=-2.823, p=0.029) or beech hedges (T=-2.705, p= 0.041) (Figure 2a). When hedge species and tube height were investigated a Scheirer-Ray-Hare test showed a significant difference between the number of signs with hedge species (χ21 =14.510, p<0.001) but not tube height (χ22 = 0.151), and there was no interaction between tube height and species (χ23 = 0.148). Post hoc analysis identified that hawthorn (T =-3.567, p=0.001) and privet (T =-2.582, p=0.029) hedges had significantly more signs than beech hedges (Figure 2b).

Table 1*.* Number of tubes with species’ footprints collected at all heights within all hedges and NHL boundaries.



Figure 2. Number of footprint tubes with mammal signs by hedge type and location. (a) Mice/vole/shrew footprint occurrence in ground level tubes according to hedge type, (b) Mice/vole/shrew occurrence according to hedge species from ground and above-ground locations. NHLB = non-hedgerow linear boundaries. Horizontal bar with black circle = median, box = interquartile range, vertical lines = range, triangle = outlier, circle with cross = mean. \* = P<0.05, \*\* = (P<0.01).

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Hair tubes

There was a significant difference in the likelihood of finding evidence of small mammal activity when comparing the three hedge species and NHL boundaries (H=9.854, p=0.020, n=40) (ground level data only). Hawthorn hedges were significantly more likely to have evidence of small mammals than NHL boundaries (T =-2.792, p=0.031, n=40) (Figure 3a). When the impact of hedge species and tube height were investigated, the Scheirer-Ray-Hare test indicated a significant difference between the number of signs with hedge species (χ22 = 12.899, p<0.01), but not with tube height (χ22 = 1.922), and there was no interaction between tube height and hedge species (χ24 = 0.300). Post hoc analysis showed that hawthorn (T = -3.294, p=0.003) and privet (T =-2.462, p=0.041) hedges had significantly more signs than beech hedges (Figure 3b).

Figure 3 Number of hair tubes with mammal signs according to hedge type and location: (a) ground level data only, (b) all levels. NHLB = non-hedgerow linear boundary. Horizontal bar with black circle = median, box = interquartile range, vertical lines = range, triangle = outlier, circle with cross = mean. \* = P<0.05, \*\* = P<0.01.

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Arboreality

Arboreality of small mammals was demonstrated in all of the hedge species using both hair and footprint tubes. There was no significant difference between the number of signs at the ground and upper level of hedges (p>0.05), but fewer were found in the middle level in hawthorn when using footprint tubes (p = 0.009) (Table 2). Shrew prints, though infrequent, and mice/vole prints were found at all levels of hedges (Table 3).

Table 2 (a) Number and percent of tubes with mice, vole, or shrew prints or tubes with signs at each level for each type of hedge. (b) Test statistics comparing the median number of signs in each type of hedgerow according to survey method.



Table 3 Number of footprint tubes with prints at each level.

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## DISCUSSION

This is a proof-of-concept that both hair tubes and footprint tubes can be used to provide evidence of small mammal activity in hedges in urban environments. Small mammals were found to use 63% of the hedges surveyed, a finding that agrees with the view of Baker & Harris (2007) that small mammals were suited to urban habitats. We also found that the species of hedge made a difference, with hawthorn and privet hedges being used significantly more frequently than beech. Also, as small mammals were detected as frequently above the ground as at ground level, the hedges were clearly being used as a three-dimensional habitat rather than simply as cover. As manoeuvring within the internal structure of hedges, and at height, presumably requires more energy expenditure than activity at ground level, there must some advantage provided by the hedge canopy. Being active above the ground may help small mammals avoid predators such as cats (*Felis catus*) (Baker et al 2005), birds (Buesching et al. 2008), and foxes (Scott et al. 2014). Canopy use may also reflect the influences of intra- and inter-specific competition and food availability (Buesching et al. 2008).

Although the two survey methods were not undertaken at the same time, both hair tubes and footprint tubes provided similar evidence of the presence of small mammals: 66% of hedges showed evidence from both methods, 94% for hair tubes, and 72% for footprint tubes. Small footprint tubes were not baited in any way, and future studies may show whether baiting influences tube efficiency. Whilst the hanging-tape approach may have deterred some individuals from entering tubes, the abundance of footprints suggests that deterrence, if any, is likely to be minimal. An improvement to future studies using hair tubes would be to identify hairs to species and to include both small and large tubes at the base of the hedge and in non-hedged linear boundaries.

This study suggests that urban hedges, even though they may be less sympathetically managed for wildlife than rural hedgerows (Faiers & Bailey 2005, Gosling et al. 2016), provide valuable wildlife habitat and are probably used as corridors for animals to move between larger green infrastructure elements. Hedges have additional benefits in pollution and noise reduction, and opportunities for human-wildlife contact (Baker & Harris 2007). Further studies incorporating mixed hedges and carried-out at other times of the year would also be beneficial.

## CONCLUSIONS

Small mammals were found to use most urban hedges surveyed and hawthorn and privet hedges were more likely to support small mammals than beech or boundaries without a hedge. Hedges also provided a three-dimensional habitat for small mammals. Both the hair tubes and the footprint tubes were effective methods for sampling in these challenging urban environments. Hair tubes provided information on presence-absence but identifying hairs to species should be a focus for future studies. In contrast, it was more straightforward to identify species or type with the footprint tubes. Our data suggest that hedges are a valuable component of urban habitats and should be protected and the resource increased.

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## REFERENCES

Anonymous (2007) *Hedgerow Survey Handbook A standard procedure for local surveys in the UK*. DEFRA, London.

Anonymous (2017) *UK Office of National Statistics – Population Statistics by Local Authority Area 1996-2036*. ONS, London

Baker, P.J., Ansell, R.A.J., Dodds, P.A.A., Webber, C.E., Phen, S.T.E. & Ris, H.A.R. (2003) Factors affecting the distribution of small mammals in an urban area. *Mammal Review* 33: 95–100.

Baker, P.J., Bentley, A.M.Y.J. & Ansell, R.J. (2005) Impact of predation by domestic cats *Felis catus* in an urban area. *Mammal Review* 35: 302–312.

Baker, P.J. & Harris, S. (2007) Urban mammals: what does the future hold? An analysis of the factors affecting patterns of use of residential gardens in Great Britain. *Mammal Review* 37: 297–315.

Baudry J, Bunce RGH & Burel F (2000) Hedgerows: An international perspective on their origin, function and management. *Journal of Environmental Management* 6: 7–22.

Benton, T.G., Vickery, J.A.& Wilson, J.D. (2003) Farmland biodiversity: is habitat heterogeneity the key? *Trends in Ecology & Evolution* 18: (4) 182–188.

Bright, P.W. (1998) Behaviour of specialist species in habitat corridors: arboreal dormice avoid corridor gaps*. Animal Behaviour* 56: 1485–1490.

Buesching, C.D., Newman, C., Twell, R. & Macdonald, D.W. (2008) Reasons for arboreality in wood mice *Apodemus sylvaticus* and Bank voles *Myodes glareolus*. *Mammalian Biology* 73: 318–324.

Dover, J. & Sparks, T. (2000) A review of the ecology of butterflies in British hedgerows. *Journal of Environmental Management* 60: 51–63.

Dunn, O.J. (1964) Multiple comparisons using rank sums. *Technometrics* 6): 241–252.

Ennos, R. (2012) *Statistics and Data Handling in Biology* Third Edition. Pearson Education Limited, Essex.

Faiers, A. & Bailey, A. (2005) Evaluating canalside hedgerows to determine future interventions. *Journal of Environmental Management* 74 (1): 71–8.

Forman, R.T.T. & Baudry, J. (1984) Hedgerows and hedgerow networks in landscape ecology. *Environmental Management* 8 (6): 495–510.

Gelling, M., Macdonald, D.W. & Mathews, F. (2007) Are hedgerows the route to increased farmland small mammal density? Use of hedgerows in British pastoral habitats*. Landscape Ecology* 22 (7): 1019–1032.

Gosling, L., Sparks, T.H., Araya, Y., Harvey, M. & Ansine, J. (2016) Differences between urban and rural hedges in England revealed by a citizen science project*. BMC Ecology* 16 (Supplement 1): 45–55.

Groot, J.C.J., Jellema, A. & Rossing, W.A.H. (2010) Designing a hedgerow network in a multifunctional agricultural landscape: Balancing trade-offs among ecological quality, landscape character and implementation costs. *European Journal of Agronomy* 32: 112–119.

Juðkaitis, R. (1999) Mammals occupying nestboxes for birds in Lithuania. *Acta Zoologica Lituanica Biodiversity* 9 (3): 19–23.

Michel, N., Burel, F. & Butet, A. (2006) How does landscape use influence small mammal diversity, abundance and biomass in hedgerow networks of farming landscapes? *Acta Oecologica* 30 (1): 11–20.

Mills, C.A., Godley, B.J. & Hodgson, D.J. (2016) Take only photographs, leave only footprints: novel applications of non-invasive survey methods for rapid detection of small, arboreal animals*. PLoS ONE* 11 (1): 1–13.

Napierala, M. (2012) What is the Bonferroni correction ? *AAOS Now* April: 1–3.

Scott, D.M., Berg, M.J., Tolhurst, B.A., Chauvenet, A.L.M., Smith, G.C., Neaves, K., Lochhead, J. & Baker, P.J. (2014) Changes in the distribution of red foxes (*Vulpes vulpes*) in urban areas in Great Britain: findings and limitations of a media-driven nationwide survey*. PLoS ONE*. 9 (6): e99059.

Staley, J.T., Botham, M.S., Chapman, R.E., Amy, S.R., Heard, M.S., Hulmes, L., Savage, J. & Pywell, R.F. (2016) Little and late: how reduced hedgerow cutting can benefit Lepidoptera. *Agriculture, Ecosystems and Environment* 224: 22–28.

Sutton, R.K. (1992) Landscape ecology of hedgerows and fencerows in Panama Township, Lancaster County, Nebraska. *Great Plains Research* 2 (2): 223–254.

Teerink, B.J. (1991) *Hair of West-European Mammals: Atlas and Identification*. Cambridge University Press, Cambridge.