

The value of green-spaces in built-up areas for western hedgehogs

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Abstract: With ongoing urbanisation an increasing number of wildlife species face rising levels of pressure due to habitat loss and fragmentation. The impact of urbanisation on species has been mainly investigated for avian life. It is however less well known how urban dwelling mammals are affected. The western hedgehog (*Erinaceus europaeus*) is closely associated with built-up areas and has recently been included in the UK Biodiversity Action Plan, as a result of evidence of significant decline in Great Britain. We studied the presence of western hedgehogs and other mammals in green-spaces in built-up areas throughout Great Britain using effort-based volunteer surveys. We used these data to investigate which factors were associated with variations in relative abundance of hedgehogs in urbanised landscapes, and to draw conclusions on which mitigation measures might benefit hedgehogs and other mammal populations. The present study suggests that the presence of wildlife friendly features, such as a hedgehog nest box and feeders, attract western hedgehogs to gardens. The presence of predators had a significant negative impact on the relative abundance of western hedgehogs in built-up areas in countryside regions. The lack of connectivity between patches of suitable habitat caused by barriers such as large water-bodies and impenetrable fences also restricted hedgehog abundance. The need for the incorporation of good environmental management, with consideration for habitat connectivity, in development planning seems to be crucial for the viability of hedgehog populations in built-up areas. Awareness amongst the public of the possibilities to increase the attractiveness of private gardens for wildlife might also increase the viability of wildlife in harsh environments.

Keywords: conservation, environmental management, *Erinaceus europaeus*, gardens, habitat fragmentation, western hedgehog, mammals, predators, urban green-spaces, volunteer survey.

Introduction

With the continued growth of the world population the expansion of urbanised areas persists. This leads to an increased pressure upon natural habitats both in rural and urban areas (Antrop 2004, Anonymous 2006, McDonald et al. 2008). Urban areas in particular are predicted to suffer an increased loss of green-spaces which is reflected by social, economic and demographic changes. Natural patches such as parks, road verges and gardens are often maintained within urban areas, and are able to support numerous populations of wildlife (Dickman 1987, Bland et al. 2004, Angold

et al. 2006). Sheltered climatic conditions, extra food supplied by wildlife friendly gardeners, compost heaps and scattered organic waste provide good situations for various species in built-up environments. Several species such as the red fox (*Vulpes vulpes*) and coyote (*Canis latrans*) are known to thrive in built-up areas (Harris & Rayner 1986, Atkinson & Shackleton 1991, Gloor 2002). Nevertheless, many examples of local extinction or declining species richness due to urbanisation can be found in literature (e.g. Czech et al. 2000, Marzluff 2005). The house sparrow (*Passer domesticus*) for instance was thought to favour built-up areas, but has been declining drastically over the last few decades (Robinson et al. 2005, De Laet & Summers-Smith 2007). Species can often cope with or adapt

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to a certain level of stress factors such as limiting habitat availability and fragmentation. However, when values reach a threshold the viability of populations can decline and once common species might become locally extinct (Hanski et al. 1996, Fahrig 2002).

Changes in built-up landscapes can have a substantial impact on species diversity and abundance in these settings (Dickman 1987, Czech et al. 2000, Baker & Harris 2007). Increasing fragmentation, housing density and loss of habitat due to rising needs for development all have negative effects on wildlife. The impact of these changes has been well studied for several mainly avian taxa such as house sparrow (*Passer domesticus*), house martin (*Delichon urbicum*), and starling (*Sturnus vulgaris*) (Crick et al. 2002, Crick et al. 2004, De Laet & Summers-Smith 2007). It is however less well known how urban dwelling mammals such as the western hedgehog (*Erinaceus europaeus*) have been affected. Mammals face high mortality risks in built-up areas due to high road and traffic densities, high levels of predation by feral and domestic pets and other predators, high concentrations of garden pesticides causing diminishing food supplies and (secondary) poisoning, and other human related disturbances (Shore et al. 1999, Wilson et al. 1999, Huijser 2000, Frid & Dill 2002, Woods et al. 2003, Ditchkoff et al. 2006).

The western hedgehog has recently been included in the UK Biodiversity Action Plan, as a result of evidence of significant decline in Great Britain (Reeve 1994, Morris 2006). The hedgehog is closely associated with green-spaces in built-up areas such as gardens, greens and parks (Huijser 1999), and it has been suggested that built-up areas might offer refugia for hedgehogs from predators (Micol et al. 1994, Young et al. 2006). Hof and Bright (unpublished data) however, state that the relative abundance of hedgehogs in Greater London has declined considerably in the last few decades. Increasing fragmentation and further loss of green-spaces in built-

up areas were thought to be the drivers behind this decline. The western hedgehog is a generalist feeder and a predator of macro-invertebrates, which are the staple diet of numerous other taxa; its decline may well signify a more general loss of environmental quality which may have important implications for environmental management. Additionally, the potential constraints faced by western hedgehogs might be even more severe for less mobile taxa that have to cope with an increasingly fragmented landscape. It is therefore important to get an understanding of the current value of green-spaces in built-up areas and to discover which particular features might enhance habitat suitability for western hedgehogs and other taxa.

The monitoring of mammals in built-up areas is subject to various constraints; problems with accessibility and visibility often arise, which makes data less valuable. Volunteer surveys have yielded valuable results in the monitoring of mammals in gardens, and provide a relatively low-cost, low time-consuming method of sampling large areas (Toms & Newson 2006, Baker & Harris 2007). Home owners were thought to spend a reasonable amount of time in or near their garden and were thought to be familiar with common and easily recognisable mammals, like the western hedgehog, red fox and badger (*Meles meles*), that may frequent their garden. We used these data in the present study to investigate the significance of habitat connectivity for hedgehogs, to investigate the impact of predators and wildlife friendly features on the presence of hedgehogs in built-up areas, and to draw conclusions on which mitigation measures in built-up areas might benefit hedgehogs and other mammal populations.

Material and Methods

The survey 'Living with Mammals' (LWM) has been designed by the Mammals Trust UK in conjunction with Royal Holloway Univer-

Table 1. The variables requested from the surveyors of the ‘Living with Mammals’ survey and used for the analyses of the dataset. * Data derived from the ‘Countryside survey 2000’ (Defra & NERC 2007).

Variable	Description
Arable in surrounding	Arable fields in surroundings (yes/no)
Box on site	Presence of hedgehog nest box (yes/no)
Built-up	Density of built-up area in 2000 (ha · 100km ²)*
Common in surrounding	Commons with rough grass or scrub in surroundings (yes/no)
Compost on site	Presence of compost heap (yes/no)
Concrete percentage	Percentage of concrete/gravel/pavings (logratio transformed)
Density badgers	The average number of badgers per min observation
Density foxes	The average number of red foxes per min observation
Density hedgehogs	The average number of hedgehogs per min observation
Feeder on site	Presence of pet feeder (non bird) (yes/no)
Fence	Site fenced (yes/no)
Gaps in fence	Gaps in the boundary large enough for hedgehogs (yes/no)
Garden in surrounding	Garden in surroundings (yes/no)
Grass percentage	Percentage of grass (logratio transformed)
Hedge	Hedge as site boundary (yes/no)
Open	No site boundary (yes/no)
Park in surrounding	Park/ village green/ residential square in surroundings (yes/no)
Pasture in surrounding	Pasture/ grass fields in surroundings (yes/no)
Pile on site	Presence of pile of dead wood (yes/no)
Pond in surrounding	Pond/ lake in surroundings (yes/no)
Pond on site	Presence of pond (yes/no)
Presence badgers	Presence badger (yes/no)
Presence dogs	Presence of dog (yes/no)
Presence foxes	Presence red foxes (yes/no)
Presence hedgehogs	Presence hedgehogs (yes/no)
River on site	Presence of river (yes/no)
Shed on site	Presence of shed (yes/no)
Shed percentage	Percentage of shed/ hut/ building (logratio transformed)
Shrubs percentage	Percentage of shrubs (logratio transformed)
Site	Type of site
Site age	Approximate age of site (4/33/82/157 years)
Site size	Approximate size of the site (13/38/126/300 ha)
Stream in surrounding	Stream/ river in surroundings (yes/no)
Trees percentage	Percentage of trees (logratio transformed)
Wasteland in surrounding	Wasteland/ derelict land in surroundings (yes/no)
Wild percentage	Percentage of wild untended areas (logratio transformed)
Woodland in surrounding	Woodland in surroundings (yes/no)

sity of London to record mammals in green-spaces within and around built-up environments. The survey took place in the period 2003-2006. During each of these years data were recorded throughout 13 consecutive weeks starting at the beginning of April. People were not only asked to record the mammals they saw; they were also asked to record site data such as location, habitat type, size and description of the site, boundary, and surrounding area. Additionally they were asked to state the approximate observation length each week per time of day (dawn, day, dusk, night). Table 1 summarises the basic data requested from the surveyors. Data about the density of built-up area were derived from the 'Country-side survey 2000' (Defra & NERC 2007)

Analysis of the LWM dataset was limited to the western hedgehog and its potential predators: the badger, and the red fox (Reeve 1994). The survey used the approximate observation length as an index for effort. The power of the effort depends on the activity pattern of the animal. Hedgehogs are for instance generally not active during the day, and if they are it is often due to reduced fitness (Reeve 1994, Morris 2006). The probability of sighting a western hedgehog during the day was therefore estimated at dawn, day, dusk and night (table 2), based on findings regarding their activity pattern (Reeve 1994). The effective recorder effort per time of day was calculated by using equation 1.

$$EE = \sum(SP_i \cdot AE_i) \quad \text{Equation 1}$$

Where *EE* is the effective recorder effort, *SP* is the sighting probability for a species during each survey period *i* (dawn, day time, dusk, and night time), and *AE* is the actual effort defined as the total number of minutes spent surveying during each survey period *i*.

Four categories of the number of individuals seen were defined in the survey: 0, 1, 2 or 3+. To calculate the total number of western hedgehogs the values of the categories were summed. The category 3+ was classified as 3.

Table 2. The probability of sighting a badger, a hedgehog and a red fox in the course of the day based on equation 1 (see text).

Course of the day	badger	hedgehog	red fox
Dawn	0.25	0.10	0.30
Day	0.00	0.00	0.10
Dusk	0.25	0.20	0.30
Night	0.50	0.70	0.30

The total number of hedgehogs recorded per site over the 13-week survey period divided by the 'total effective recorder effort' represented the number of hedgehogs sighted per minute per site and was used to provide an index of relative abundance. Unfortunately it was impossible to account for potential duplication of hedgehog sightings. We made the assumption that the likelihood of seeing a western hedgehog has a positive and linear correlation with their relative density; a fixed amount of recording effort will result in seeing a fixed proportion of the population. This implies the assumption that the relative density is proportional to the factual density and that the rate of proportionality is constant (Schwarz & Seber 1999). In order to obtain an estimate of the minimum number of sites that have to be surveyed to gain confidence in the estimated relative density of hedgehogs, the mean number of hedgehogs observed per site was calculated using random sub-samples (ranging from 0-1700 with steps of 100). The mean relative density of badgers and foxes was calculated in a similar way. The probability of sighting a badger and a red fox in the course of the day was estimated as well (table 2), based on their general activity pattern (Harris & Yalden 2008). Relative abundance of badgers, red foxes, and western hedgehogs was estimated for 'built-up areas in the countryside' (henceforth called countryside) (built-up <50%; derived from the 'Country-side survey 2000' (Defra & NERC 2007)), 'urban areas' (built-up >50%), and both areas together. This gives an indication of the rela-

tive abundance of the different species in different surroundings.

To estimate the area occupied by grass, shrubs, trees, concrete, sheds and wild areas within the individual survey sites, the logratios of the five categories set on the survey sheet (0%, 1-25%, 26-50%, 51-75%, 76-100%) were taken (Aitchison 1982, Kucera & Malmgren 1998). Averages of the different categories have been taken to estimate the age and the size of the site (see table 1 for the categories). Only variables that might have an impact on the presence of western hedgehogs were included in the database (table 1). Therefore, data such as the presence of domestic cats and birdbaths were discarded. We used Pearson Chi-Square and Pearson Correlation in SPSS (for windows 14th edition, SPSS Inc., Chicago, USA) to study whether the presence of hedgehogs was significantly related to the variables. Student *t*-test and the nonparametric Kruskal-Wallis test have been used by us to study the differences in population means. We used Generalized Linear Modelling, (GLM) modelling of binomial proportions by transformation logit in the programme GenStat (for windows' 8th edition, VSN International Ltd, Lawes Agricultural Trust, Oxford, UK) to explain the variation in relative hedgehog abundance. The models were built manually using the backward stepwise method. Minimal adequate models were selected based upon the Akaike Information Criterion (Akaike 1981). The effective recorder effort was used as a weight factor to correct for differences in recorder effort. Different models were built for different environmental zones within Great Britain in order to reduce the impact of the general environment on differences in hedgehog abundance. Environmental zones were defined by the 'Countryside Information System' and formed from aggregations of the 40 base classes of the ITE land classification of Great Britain (figure 1) (Bunce et al. 1996, Defra & ADAS 2005). Models were built for the arable-dominated and the pasture-dominated lowlands in

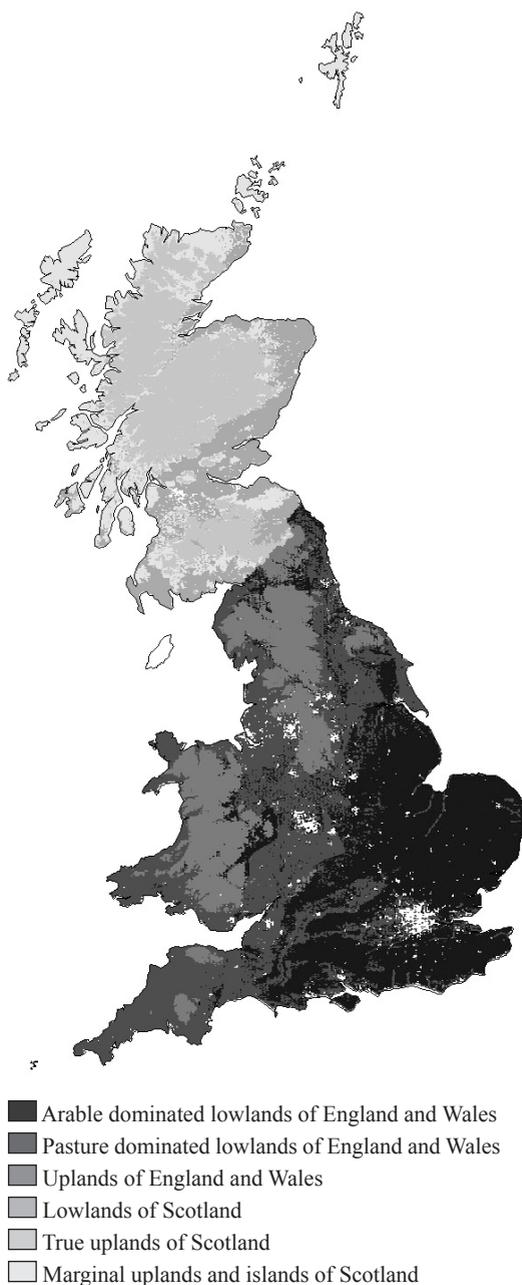


Figure 1. The environmental zones of Great Britain as defined by the Countryside Information System (Defra & NERC 2005).

England and Wales only, due to insufficient records to build minimum adequate models for the other environmental zones.

Results

In total 1711 sites were surveyed. Figure 2 shows the distribution of the sites throughout Great Britain and shows on which sites badgers, red foxes and western hedgehogs have been found and on which sites they were thought absent. Figure 3 shows the mean relative abundance of badgers, red foxes and hedgehogs per region. Differences in mean relative abundance per region were significant for badgers (Kruskal-Wallis: $\chi^2=25.115$, $df=10$, $P=0.005$), red foxes (Kruskal-Wallis: $\chi^2=84.716$, $df=10$, $P=0.001$), and hedgehogs (Kruskal-Wallis: $\chi^2=39.158$, $df=10$, $P=0.001$). Western hedgehogs were relatively more abundant in the eastern regions of England and in the West-Midlands compared to all other regions of Britain, whereas badgers were relatively more abun-

dant in the southwestern regions of England and in Scotland. Red foxes were relatively most abundant in Greater London and in the South-East of England.

Figures 4A, B and C show the mean number of badgers, red foxes and western hedgehogs seen per minute observation in built-up areas in the countryside, urban areas, and both areas together. Although an asymptote has not been reached in every situation, a clear distinction can be seen for red foxes. The average relative abundance for red foxes was significantly lower in built-up areas in the countryside than in the urban areas (Student t-test: $t=-2.106$, $df=1192$, $P=0.035$), whilst this trend was reversed for badgers and hedgehogs. These differences however were not statistically significant.

The GLM was able to explain 42% of the variance in presence of hedgehogs in gardens

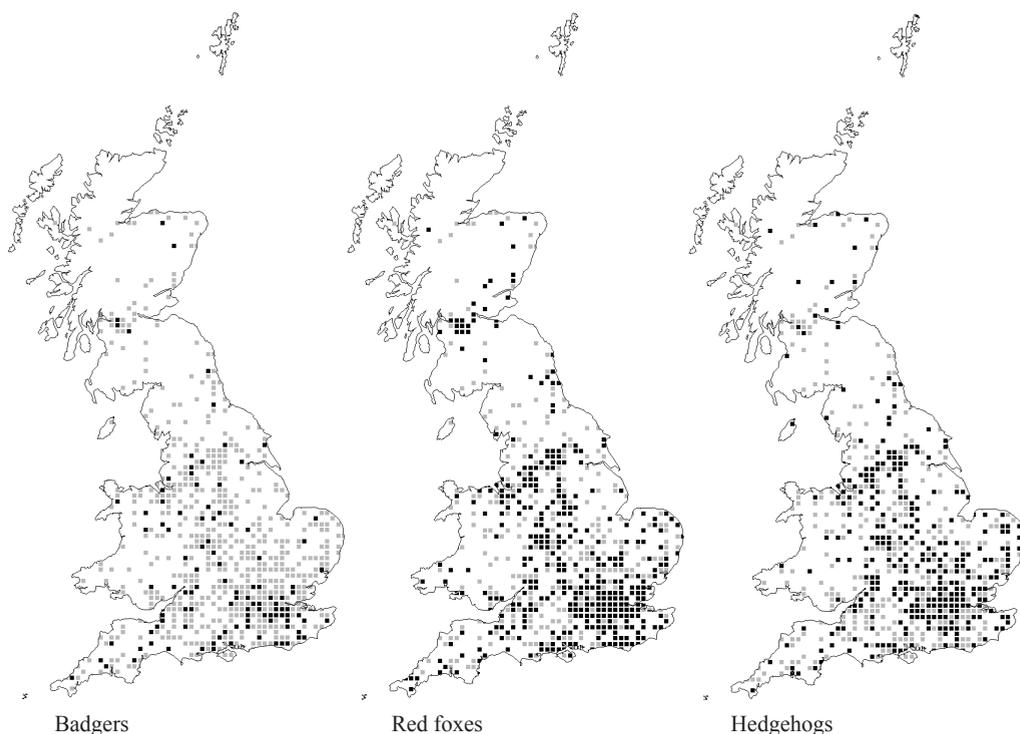


Figure 2. The locations of the participants of the LWM survey 2003-2006. Black dots show where the species has been found and grey dots show where the species has not been found. Badger: presence $n=153$, absence $n=1558$. Red fox: presence $n=823$, absence $n=888$. Western hedgehog: presence $n=515$, absence $n=1196$.

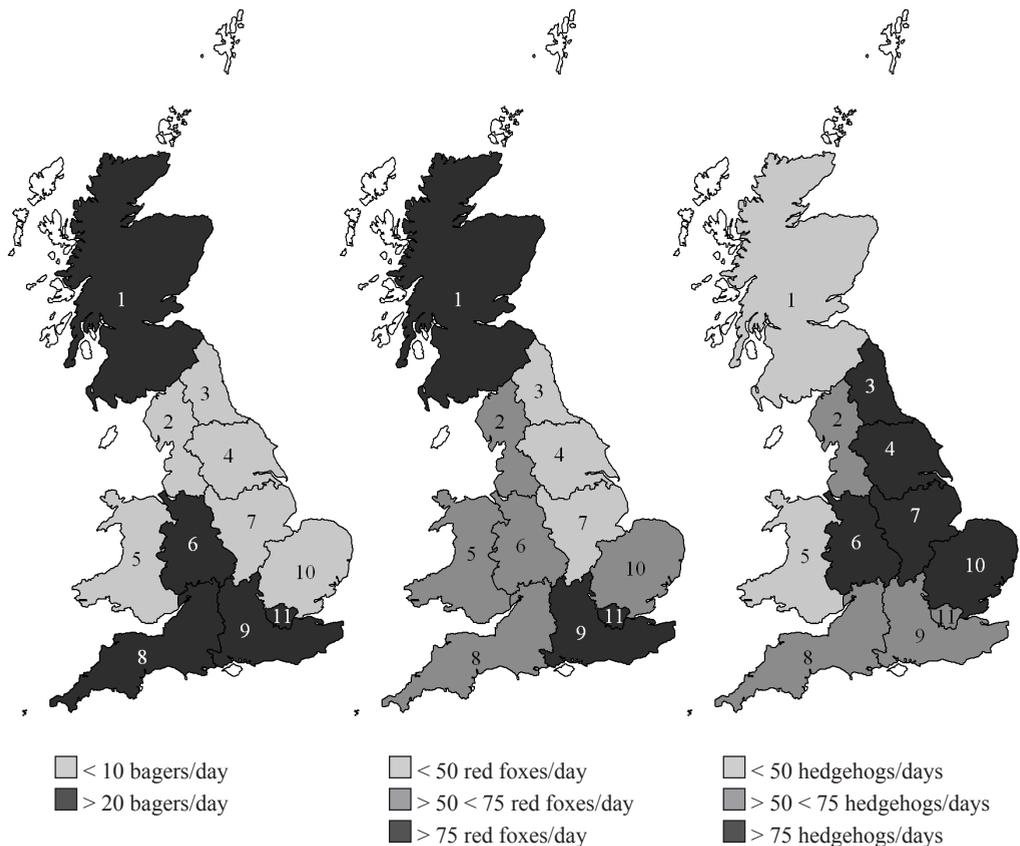


Figure 3. Mean relative abundance of badgers, red foxes and western hedgehogs seen per day of continuous observation per region of Great Britain, with 1. Scotland, 2. Northwest of England, 3. Northeast of England, 4. Yorkshire and The Humberside, 5. Wales, 6. West-Midlands, 7. East-Midlands, 8. Southwest of England, 9. Southeast of England, 10. East of England, and 11. Greater London.

in the pasture-dominated lowlands and 54% in gardens in the arable-dominated lowlands of England and Wales. Table 3 shows the summary of the models. The variable 'pasture in the surroundings' was able to explain the highest percentage of variance (21%) in the arable-dominated lowlands. The availability of a large amount of shrubs and or a pond or lake at or in the surroundings of the site and the presence of a feeder at the site, were also positively correlated with hedgehog presence. Western hedgehogs were on the other hand less often seen at sites also frequented by badgers. The presence of a hedgehog nest box had the highest explaining power (10%) in the pasture-dominated lowlands. A hedge-

hog nest box, feeders on site, a large percentage of grass on the site, gaps in the boundary, and a common, woodland or a park in the surrounding of the site were all positively related to hedgehog presence. In this environmental zone, hedgehogs were less often seen in gardens that had arable in the surroundings, high densities of built-up areas, or domestic dogs and/ or badgers frequenting the site. A river through the site was also negatively related to hedgehog presence.

Western hedgehogs were found on 30% of all the sites, whilst red foxes were found on 48% and badgers only on 9%. Domestic dogs (*Canis lupus familiaris*) regularly frequented 36% of the sites. The presence of badgers had

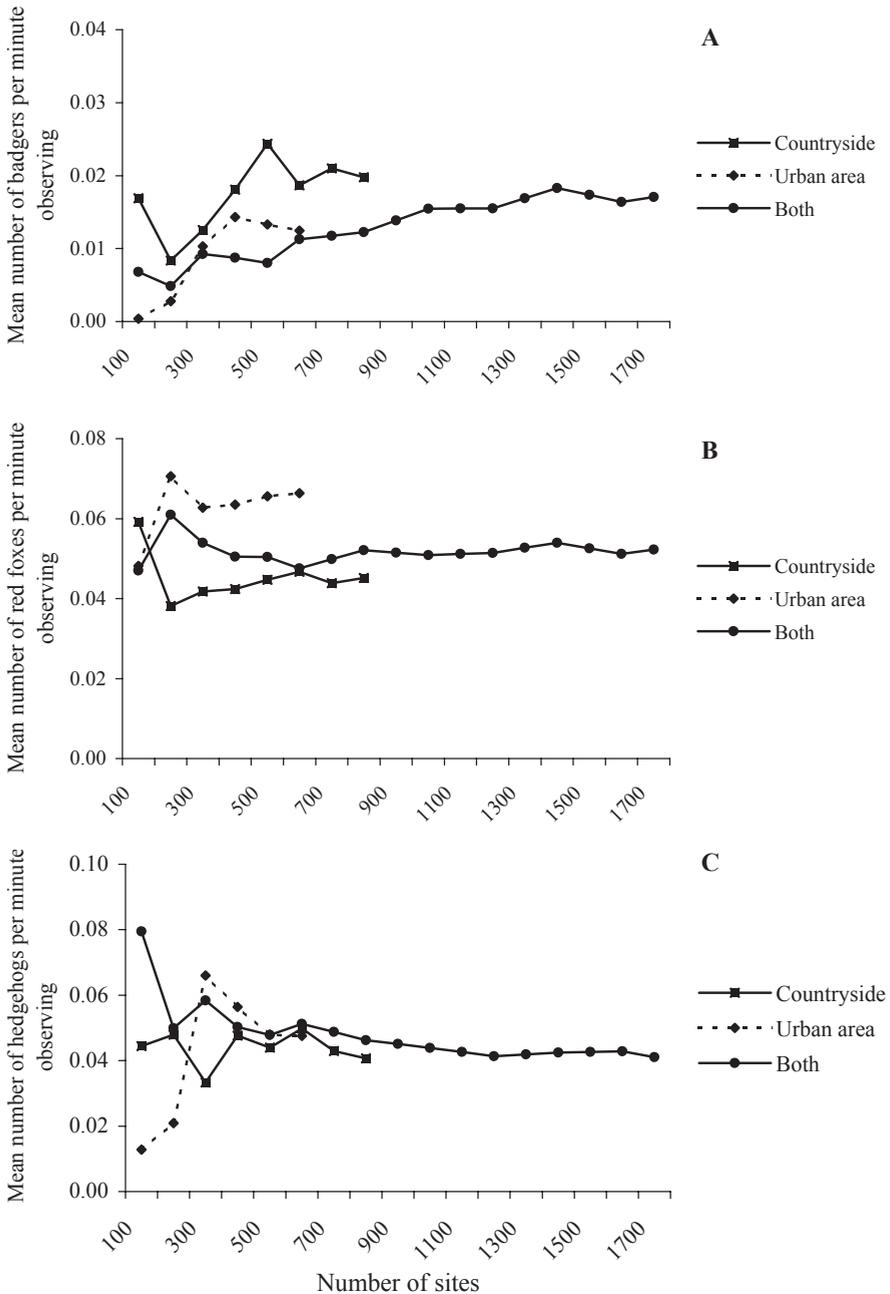


Figure 4. The average number of badgers (A), red foxes (B) and western hedgehogs (C) per minute observing versus the number of sites in the countryside, in the urban areas and in both areas, in the period 2003-2006. Standard deviations are not shown for clarity. (Average standard deviation: badger countryside = 0.110, badger urban area = 0.077, badger both areas = 0.102, red fox countryside = 0.142, red fox urban area = 0.148, red fox both areas = 0.143, hedgehog countryside = 0.151, hedgehog urban area = 0.220, hedgehog both areas = 0.210).

Table 3. Summary of the two GLMs (modelling of binomial proportions by transformation logit) for the arable and pasture-dominated lowlands of England and Wales with dependent variable ‘hedgehog presence’, and ‘effective recorder effort’ as the weighing factor.

Hedgehog presence in gardens 2003-2006	Variable	Estimate	<i>r</i> ²	<i>P</i>
Arable-dominated lowlands of England and Wales Explained: 42%, <i>n</i> =380, <i>P</i> <0.001	Constant	-5.370		<.001
	Feeder on site	1.699	0.037	<.001
	Pasture in surrounding	3.043	0.205	<.001
	Pond in surrounding	2.607	0.104	<.001
	Pond on site	1.986	0.076	<.001
	Presence badgers	-3.557	0.091	<.001
Pasture-dominated lowlands of England and Wales Explained: 54%, <i>n</i> =285, <i>P</i> <0.001	Shrubs percentage	1.544	0.023	<.001
	Constant	-2.498		<.001
	Arable in surrounding	-3.927	0.092	<.001
	Box on site	3.611	0.097	<.001
	Built-up	-2.282	0.059	<.001
	Common in surrounding	1.648	0.043	<.001
	Feeder on site	1.997	0.034	<.001
	Gaps in fence	3.122	0.030	<.001
	Grass percentage	1.200	0.023	<.001
	Park in surrounding	1.980	0.035	<.001
	Presence badgers	-2.816	0.027	<.001
	Presence dogs	-1.625	0.030	<.001
River on site	-4.897	0.086	<.001	
Woodland in surrounding	1.735	0.041	<.001	

a significant negative effect on the presence of hedgehogs in survey sites classified as countryside areas (Chi-square test: $\chi^2=4.447$, *df*=1, *P*=0.035), but not in survey sites classified as urban areas. A similar situation arose with the presence of dogs, with a significant negative impact in the countryside (Chi-square test: $\chi^2=4.533$, *df*=1, *P*=0.033), but not in the urban areas. The presence of red foxes on the other hand was not significantly related to the presence of hedgehogs. When all the potential predators, badgers, red foxes, and domestic dogs, frequented the site, there was a larger significant negative impact on the presence of hedgehogs than the negative impacts from badgers and dogs separately (Chi-square test: $\chi^2=7.573$, *df*=1, *P*=0.006).

Discussion

The present study suggests that western hedgehogs are likely to be present in a higher relative abundance in the eastern regions of England and in the West Midlands than in other areas of Great Britain. In contrast, the eastern regions of England were characterized by a low relative abundance of badgers and largely as well by a low relative abundance of red foxes. It seems straightforward to suggest that a negative relation exists between the abundance of potential predators and the abundance of hedgehogs. The presence of badgers was indeed negatively correlated with the presence of hedgehogs in both the arable and the pasture-dominated low-

lands of England and had a significant negative effect on the presence of hedgehogs in survey sites in countryside areas. The negative impact of badgers on hedgehogs has also been shown by other studies (Doncaster 1992, Doncaster 1994, Micol et al. 1994, Young et al. 2006). However, in urban areas this negative impact of badgers was not clear. Although the presence of hedgehogs was also negatively affected by the presence of badgers here, the relationship was not statistically significant. The fact that the density of badgers was higher in countryside areas than in urban areas might explain the different impacts upon the presence of hedgehogs between these two environments. Nonetheless, sett densities can be high in urban areas and more and more conflicts with badgers have consequently arisen in recent times (Delahay et al. 2009). Although it is known that red foxes frequently roam in gardens in urban areas (Harris 1986, Gloor 2002), they did not seem to negatively affect the presence of hedgehogs. Domestic dogs however also often wander freely in gardens, especially in more rural areas, and are known to inflict injuries upon hedgehogs and occasionally kill them (Doncaster 1994, Reeve 1994). Western hedgehogs were indeed less often seen on sites that were frequented by domestic dogs. Although no statistically significant relationship existed in urban areas, a negative impact of dogs on the presence of hedgehogs was visible in countryside areas, where the prevalence of dogs was higher in the present survey. Additional to the higher dog density in countryside areas, dog owners in these areas might more frequently have several dogs than dog owners in urban areas thus creating a higher density per km², which will inevitably be of greater significance to hedgehogs. The GLM for the pasture-dominated lowlands also showed a negative impact of dogs on hedgehog presence. Thus, the present study suggests that the presence of predators can indeed have a significant negative impact on the presence of hedgehogs. Increasing numbers of predators

both in rural and in urban areas might lead to local extinctions of prey species (Holyoak & Lawler 1996). Predator control is frequently practised in order to protect prey species (Reynolds & Tapper 1996). Though, since both practical and ethical issues are likely to arise whilst culling one species in order to protect the other, it seems imperative to seek more effective and non-lethal methods to preserve prey species. The control of the number of pets such as dogs will undoubtedly be even more prone to difficulties. Non-invasive mitigation measures might therefore prove more time and cost efficient.

People in general like to have wildlife in their gardens and therefore often try to increase the attractiveness of their garden for wildlife. Features in gardens that were attractive to hedgehogs in the present study were a high percentage of shrubs and grass, the presence of a pond, the presence of a hedgehog nest box, and the availability of extra food sources. It is likely that some of the people decided to place a hedgehog nest box in their garden after first seeing a hedgehog there. It therefore cannot be concluded from these data that a hedgehog nest box itself will attract hedgehogs to gardens. Nevertheless a hedgehog nest box does provide shelter and a suitable nest site location which might indeed encourage hedgehogs to return to those sites that include one. Well established and dense shrubbery is also able to offer shelter and nest sites to hedgehogs (Morris 2006). Hedgehogs can often be found at food bowls put out in gardens to feed pet and feral cats or other mammals (Morris 2006). It is therefore not surprising that hedgehogs were more often seen in gardens by people that provide food for wildlife. It has also been shown by other studies that wildlife friendly features may favour the presence of other taxa (Baker & Harris 2007). Raising awareness amongst the general public and stressing the importance of wildlife friendly features in private gardens is therefore likely to benefit wildlife in general.

Many gardens are at least partly fenced

which limits the accessibility for large and medium sized mammals. Gaps in boundaries of gardens did indeed have a significant positive effect on the presence of hedgehogs in the pasture-dominated lowlands, provided they were large enough, and will enhance the connectivity between suitable habitats, thereby enlarging the area available to hedgehogs. It was therefore not surprising that the occurrence of green-spaces like parks, commons and woodlands in the surroundings of the site positively affected the presence of hedgehogs. Streams and rivers were significantly related to a low presence of hedgehogs, although hedgehogs are able to swim and are known to have crossed large water bodies (Doncaster 1992); they do seem to reduce connectivity through creating partial barriers. Connectivity between patches of habitat in fragmented landscapes by good quality dispersal routes is frequently deemed essential for the prevalence of viable populations of various taxa (Fahrig & Merriam 1985, Fahrig & Merriam 1994, Beier & Noss 1998). Green-spaces in heavily urbanised areas however are frequently not interconnected and also lack good quality dispersal routes. Ongoing urbanisation and the need for new developments will doubtlessly further decrease habitat connectivity. The viability of populations of various taxa will be jeopardized by further habitat loss and fragmentation if their critical thresholds in habitat connectivity are reached (Mönkkönen & Reunanen 1999, Fahrig 2002, Ovaskainen et al. 2002). Unfortunately the density of roads in the direct surroundings of the site could not be included in the GLM, since these data were not provided by the surveyors. However, possible impacts of roads should not be ignored. Especially large roads were infrequently crossed by hedgehogs in an experiment by Rondinini and Doncaster (2002); nevertheless work by Doncaster et al. (2001) has shown that road verges can work as movement corridors for hedgehogs and thus roads in such do not form impenetrable barriers to hedgehogs. Bergers and Nieuwenhuizen (1999) also state that the viability of hedgehog populations

decreased dramatically as a result of fencing roads. Roads on the other hand can form a barrier to hedgehogs because of the risk of death caused by traffic. Large numbers of hedgehogs die every year on roads (Huijser 2000, Morris 2006), and Huijser (2000) suggests that roads and traffic may reduce hedgehog populations by up to 30% in the Netherlands.

Conclusions

The present study suggests that the presence of predators like the badger and the domestic dog can limit the number of western hedgehogs found in built-up areas in the countryside. Ongoing study might clarify the extent of this impact and identify mitigation measures. Wildlife friendly features on the other hand do increase the suitability of green-spaces in urbanised landscapes for hedgehogs. Awareness amongst the public of the possibilities to increase the attractiveness of private gardens for wildlife, and of the restrictions fences and free roaming pet dogs pose on the movements of various mammal species, might increase the viability of wildlife populations in areas where they face the threat of increasing urbanisation. Additionally, the need for the incorporation of good environmental management, with consideration for habitat connectivity, in development planning seems to be highly important for the viability of hedgehog populations and likely for other mammal species as well.

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Samenvatting

Het belang van groene gebieden in stedelijke omgeving voor egels

Een stijgend aantal dieren en planten krijgt te maken met een verhoogde mate van stress door het verlies aan en fragmentatie van habitat door verdergaande urbanisatie. De invloed van urbanisatie is met name onderzocht met betrekking tot vogels. Het is beduidend minder duidelijk wat de eventuele invloed van urbanisatie is op zoogdieren. De egel (*Erinaceus europaeus*) wordt over het algemeen nauw geassocieerd met (sub)urbane gebie-

den en kan, naar gedacht, relatief hoge verstoringen verwerken. De egel is echter sinds kort opgenomen in het actieplan voor biodiversiteit van het Verenigd Koninkrijk 'UK Biodiversity Action Plan', als resultaat van een significante daling in het aantal egels. De aanwezigheid van egels en andere zoogdieren in groene gebieden in (sub)urbane gebieden verspreid over Groot-Brittannië is onderzocht met de hulp van vrijwilligers. De data zijn gebruikt om te onderzoeken welke factoren variaties in relatieve dichtheden aan egels kunnen verklaren in (sub)urbane gebieden. Ook werd getracht te bepalen welke maatregelen voor egels en andere zoogdieren gunstig zouden kunnen zijn. De huidige studie suggereert dat de aanwezigheid van bijvoorbeeld speciaal uitgezet voedsel voor dieren en voldoende struikgewas, egels naar tuinen lokt.

De aanwezigheid van potentiële predatoren, zoals de das en de hond, had echter een significante negatieve invloed op de aanwezigheid van egels in tuinen; met name in bebouwde gebieden op het platteland. Het gebrek aan connectiviteit tussen gebieden met een geschikt habitat, door barrières zoals rivieren en omheiningen, had ook een negatieve uitwerking op het aantal egels. Het is dan ook van groot belang dat de aandacht gevestigd wordt op de connectiviteit van habitat bij nieuwe stedelijke ontwikkelingsplannen. Besef van het belang van connectiviteit en van dier- en plantvriendelijke tuinen bij de bevolking zou het perspectief van de flora en fauna in stedelijke gebieden ook kunnen vergroten.

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