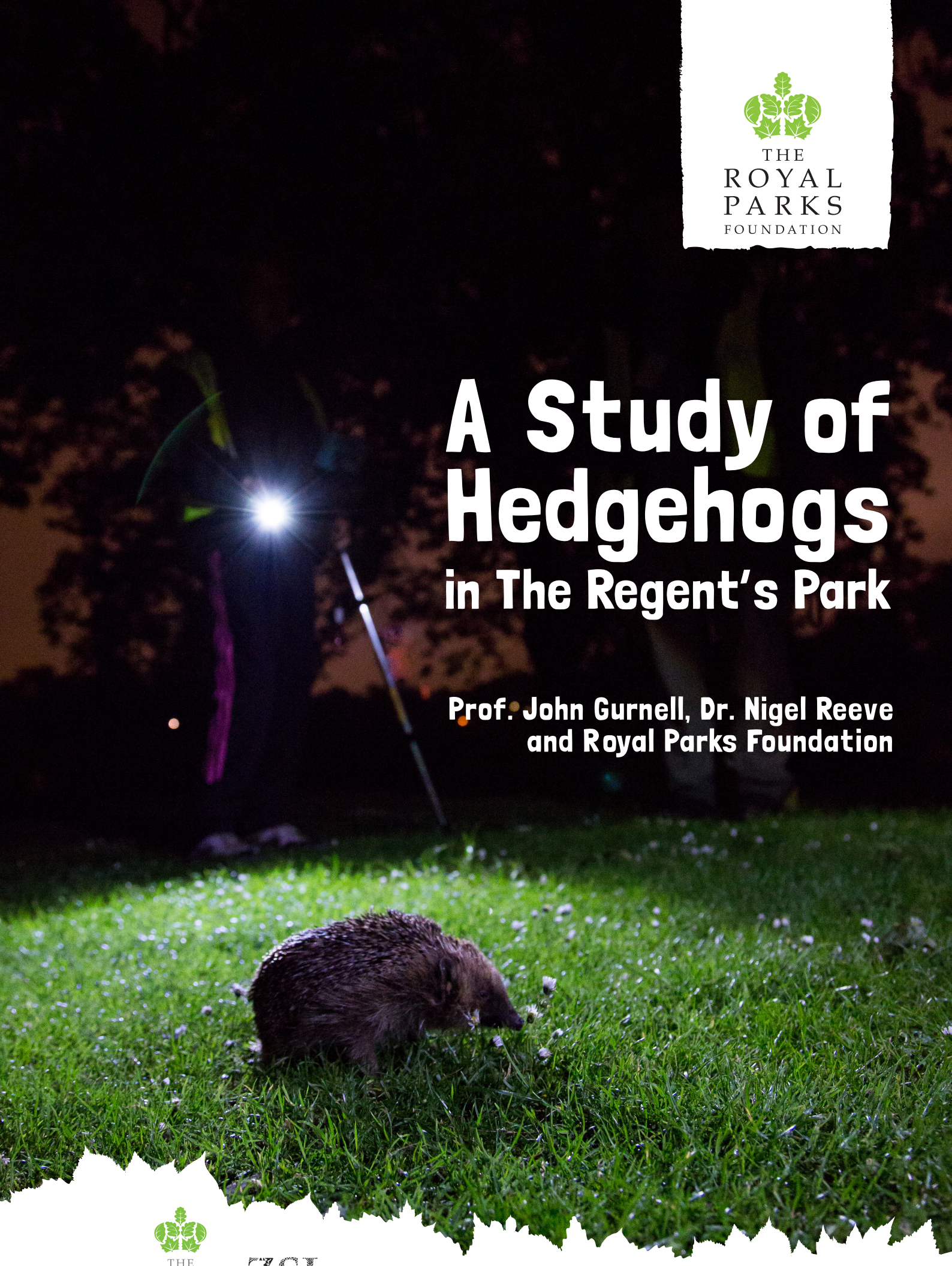

THE ROYAL PARKS FOUNDATION

A Study of Hedgehogs in The Regent's Park

Prof. John Gurnell, Dr. Nigel Reeve and Royal Parks Foundation

WORKING IN PARTNERSHIP WITH THE ROYAL PARKS

ZSL LIVING CONSERVATION

May & September 2014

Executive summary

The European hedgehog *Erinaceus europaeus* is a familiar and widespread insectivorous mammal, but there is strong evidence that it is in serious decline in Britain; especially in London and the South East. Hedgehogs are a UK Priority Species for conservation and partially protected under the Wildlife and Countryside Act (1981 as amended). In the early 1970s hedgehogs were reported to be present in all London's central Royal Parks. They have since disappeared from all central London sites except The Regent's Park. The Regent's Park is one of London's eight Royal Parks managed by The Royal Parks who directly manage about 124 ha of this 166 ha site. The reasons for the decline and local extinctions in central London's hedgehog populations are unknown, but habitat fragmentation and the isolation of sites within the urban matrix, as well as issues to do with habitat management, are likely to be significant factors. Recent sightings confirm that hedgehogs are still present in The Regent's Park, but this study is the first to examine the population size, ranging behaviour and habitat use of the hedgehogs living there.

Our study used five complementary survey methods to gather as much information about the hedgehogs as possible during two intensive study periods; 19-31 May and 5-15 September 2014. Animals were detected using footprint tunnels, camera trapping and spotlighting (systematic searching on foot with the aid of torches). Radio tracking (VHF) and GPS tracking of selected hedgehogs provided more detailed data on movements and behaviour. Key to the success of this partnership project was the involvement of 53 (May) and 43 (September) volunteers. This total of over 68 individuals, together with the project supervisors, worked a total of 1,165 hours (over 47 person-days) in the field. Volunteers were provided with training, equipment and comprehensive documentation. ZSL Veterinary Services provided essential veterinary support.

Of 65 footprint tunnels placed in a broad range of habitats in May (238 tunnel inspections) and 8 in September (36 inspections) none detected hedgehogs footprints, although a range of rodents and other non-target species were recorded. Up to ten camera traps were positioned in the Park in association with footprint tunnels. Most videos were of rodents, but foxes featured in12% (May) and 22% (September) of videos. Hedgehogs accounted for 6% (May) and 2% (September) of video detections but none entered the tunnels. Four cameras were set up in strategic locations within the ZSL grounds for 10 days in September but detected no hedgehogs.

In contrast to the results from footprint tunnels and camera traps, spotlighting proved to be an effective way of detecting hedgehogs with 27 individuals identified in May and 41 in September. Persistence of individuals from May to September was 69% (females) and 38% (males). The presence of 5 youngsters in September confirmed that this was a breeding population. Eleven of the 14 new adults found in September were from the ZSL car park; an area not searched in May.

The hedgehogs found were generally in good condition with above average body weights. Mean adult weights were 932 g (males) and 950 g (females) in May and, respectively, 1000 g and 975 g in September. It is normal to find some injuries or illnesses within a wild population, although none was found in September. In May, three animals with problems typical of wild hedgehogs were referred to veterinary surgeons. One was re-released after treatment. However also in May, six hedgehogs (includes one referred for an ear infection) presented with leg fractures or amputations, three of which had healed, but three of which were fatal injuries. The cause of these injuries is unknown but predator attack is one possibility. We recommend a fox census be carried out as well as a consideration of all possible causes of such injuries that could result from human action.

The combined use of VHF radio tracking and GPS tags successfully revealed the ranging behaviour and movements of a total of 16 hedgehogs. Ranging behaviour, as shown by GPS tag data, was normal for the species and generally consistent with other studies of European hedgehogs in terms of both nightly distance travelled (mean 798 m) and the area covered each night (mean 1.79 ha: 95% kernel estimation). These figures do not include one wide ranging male in May.

The limited accuracy of GPS location fixes highlighted the need for nest locations to be verified by radio tracking on foot and for direct behavioural observations to determine habitat use patterns. Nevertheless, our GPS and radio tracking data both indicate a preferential use of amenity grassland (parkland) as foraging habitat and of informal shrubberies as nesting habitat. There was a negative preference for more formal planted flower beds and shrubberies.

Spotlighting, GPS and radio tracking data all show that hedgehogs never visited the sports pitches and made almost no use of the open grassland on Cumberland Green or Gloucester Green, although Marylebone Green was heavily used. Areas of greatest hedgehog activity were three 'hotspots': Zone 1 the Avenue Gardens and Marylebone Green, Zone 2 the area around the ZSL car park, and Zone 5 Queen Mary's Gardens and the area around the Boating Lake. We conclude that large areas of open grassland (principally sports pitches) are avoided by hedgehogs but that grassland within a fine-scale mosaic of formal and informal shrubberies and hedges is an important resource. Our report specifies a set of detailed recommendations in relation to optimising foraging and nesting habitat, and providing habitat continuity.

Allowing for some undetected individuals we estimate the September population to be small; in the region of 50 individuals. This is within the lower range of a minimum viable population calculated for a site of this size. The presence of hedgehog-specific ectoparasites (fleas and ticks) suggests that this is a wild relict population. However, we have no information as to whether hedgehogs (either wild-caught or released captives) have been introduced into the park at any time in the past.

Such a small hedgehog population is vulnerable. Therefore, risk to hedgehogs should be an integral factor in evaluating any management procedures or changes of use. This should apply to the whole park but the three 'hotspots' identified should be particularly safeguarded. Measures to enhance habitat quality for hedgehogs should begin without delay and we recommend further behavioural studies to refine our understanding of how hedgehog utilise the available habitats.

Given the vulnerability of the population, we advise regular spotlighting surveys, repeated annually, to provide a time-series of systematic counts to establish whether or not this is a declining population.

Although all recorded hedgehog movements were confined within the park, our study was not able to confirm how isolated this population may be. Key to the future management of hedgehogs on this site is a better understanding of the degree of spatial and genetic isolation of the population. As well as collecting more data on hedgehog movements, we also recommend further spotlighting survey work of nearby green spaces, a questionnaire study of local residents concerning their experiences of local hedgehogs and a study on genetic diversity using molecular markers.

This partnership project has successfully engaged with the community, and has yielded a great deal of new information about this previously unstudied hedgehog population. The findings and recommendations may help other urban park managers to manage and maintain their sites in a 'hedgehog-friendly' way so as to conserve other potentially vulnerable and declining populations of this popular mammal.

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1. Introduction

The European hedgehog *Erinaceus europaeus* is a familiar and widespread insectivorous mammal, but there is strong evidence that it is in serious decline in Britain (Wembridge, 2011; Macdonald & Burnham, 2011; PTES, 2013); especially in London and the South East (PTES, 2010). The decline of hedgehogs seems to be a long-term trend first noted by Tapper (1992) from an analysis of gamekeepers' trapping records, and a questionnaire study of members of the National Federation of Women's Institutes (Morris, 2006). Such general indications of long-term decline are supported by an analysis by Hof (2009) who found a decline in recorded occupancy of 10km^2 grid squares in England of 16% between the periods 1960-1975 and 2005-2006.

1.1 National hedgehog decline

Recent national surveys include *Mammals on Roads* (using rural road-kill counts), *HogWatch* and *Living with Mammals* (citizen reports largely from urban private gardens) funded by the Mammals Trust UK (MTUK) and in collaboration with Royal Holloway and the British Hedgehog Preservation Society. Road casualty records suggest that hedgehog numbers may have halved between 1990 and 2001 (Macdonald & Burnham, 2011). Counts of mammals were experimentally added to the British Trust for Ornithology (BTO) Breeding Birds Survey 1995-2002, but the records for hedgehogs were insufficient to show trends in abundance and were largely derived from 'local knowledge' and the recording of dead animals (Newson & Noble, 2005). Recent data from the *Living with Mammals* survey shows a continuing downward trend (Figure 1.1).

Based on the evidence of significant national decline, hedgehogs were added to the UK Biodiversity Action Plan (BAP) in 2007 as a UK priority species for conservation.

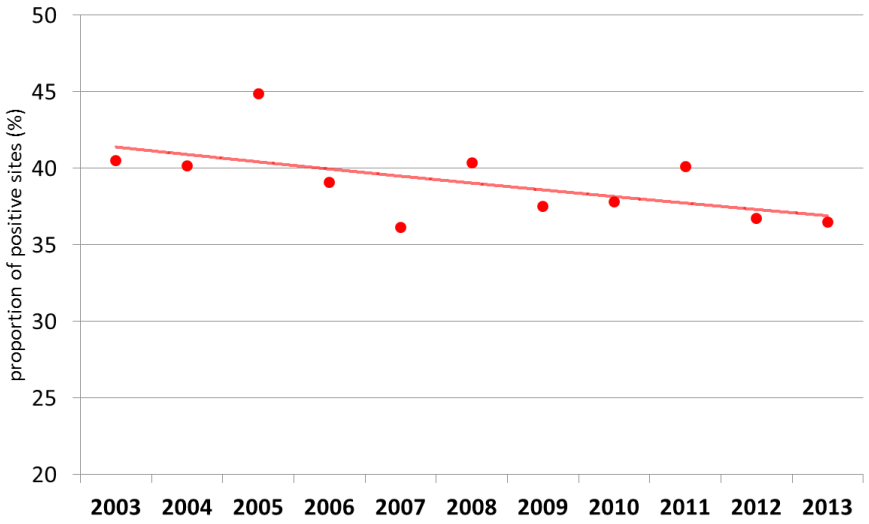


Figure 1.1 The proportion of sites recording hedgehogs in each year of the national *Living with Mammals* survey. The trend line indicates a reduction of about 5% over 10 years. Source: PTES (2013).

Box 1. Likely causes of decline in hedgehog populations A good review of likely factors causing national hedgehog decline, including the effects of climate-change, is provided by Hof, 2009. However, we still know little about the true extent and specific causes of the hedgehog decline. Probably, different combinations of negative factors operate on urban and rural sites, and some factors may be particularly local and site-specific. For the present study the most relevant potential causes of decline are:

i. **Habitat loss**: the destruction of suitable habitat by development (building construction) or land use change that removes key habitat requirements for hedgehogs such as areas suitable for nest-building or foraging for invertebrate prey.

ii. **Habitat degradation**: deterioration in habitat quality so that it becomes less suitable for hedgehogs. This includes the use of pesticides or management/cultivation changes that reduce the availability of invertebrate prey or the creation of large open areas without available cover.

iii. **Habitat fragmentation**: the connectivity of suitable habitat in the landscape is interrupted by walls, fences, roads and other man-made features that prevent the free movement of hedgehogs or make such movements more hazardous with exposure to road traffic or an increased risk of predation. The probability of extinction for local populations increases with isolation and smaller habitat patch size.

iv. **Agricultural intensification**: although less directly relevant to central London, it is responsible for major changes in the landscape and overall UK biodiversity. It includes elements of habitat loss, degradation and fragmentation as well as the wide-scale negative effects of pesticide use on the abundance of invertebrate prey.

v. **Pollution**: a wide range of persistent environmental pollutants (e.g. heavy metals, arsenic, chlorinated and brominated organic compounds) have been shown to accumulate in hedgehog tissues (D'Have, 2006). Such ecotoxins have the potential to cause sub-lethal effects including endocrine disruption. In Belgium, D'Have (2006) found associations with the concentrations of certain pollutants with some reproductive hormone levels, but was able to reveal only minor or negligible evidence of pollutant effects on the endocrine system and reproduction.

vi. **Predator attack**: injury and death particularly from badgers, foxes and domestic dogs. Domestic dogs are abundant but generally present in daylight when hedgehogs are typically inactive, but they may disturb and attack nestling or adult hedgehogs in their nests. High densities of badgers are associated with the absence of hedgehogs (Micol *et al.,* 1994) and co-existence with badgers may constrain hedgehog population size (Trewby *et al.,* 2014) but there are no badgers in Central London and a similar negative relationship has not been demonstrated for foxes.

vii. **Road mortality and other anthropogenic hazards**: Wide-ranging but relatively slow-moving, hedgehogs are vulnerable to death and injury from road traffic accidents. Huijser and Bergers (2000) in The Netherlands showed that hedgehog populations in the vicinity of roads were reduced by 30%. There are many other anthropogenic hazards which include steep-sided waterbodies in which hedgehogs may become trapped. Hedgehogs are also vulnerable in their nests by day to the widespread use of brush-cutters, strimmers and mowing machines.

1.2 Sustaining an urban hedgehog population

The principal requirements of a sustainable urban hedgehog population can be inferred from our knowledge of their natural history, as reviewed by Reeve (1994). Hedgehogs require undisturbed areas of undergrowth, in which to nest at all times of year and a supply of fallen dead leaves as nesting material. Hedgehogs may also nest in woodpiles or in spaces under sheds or other such structures. They feed mainly on a wide variety of ground invertebrates and particularly exploit edge habitat bordering hedgerows, shrubberies, wooded areas. Urban and suburban hedgehogs can persist in biodiverse 'hedgehog-friendly' gardens and public green space provided that these are accessible at ground level and well connected to other areas of suitable habitat with few hazards. The tendency to keep parks, gardens, roadsides and other green spaces looking neat and tidy often results in the clearance of suitable nest sites and grassland rich in ground invertebrates in a way unsympathetic to the needs of hedgehogs. They are wide-ranging animals that may routinely travel one kilometre or more in search of food in a single night and sexually active males may move three times that distance in search of females (Reeve, 1994). Therefore they need to be able to move efficiently and safely between habitat patches, but walls, fences and other structures often prevent such movement. The benefits to hedgehogs of defragmentation of the urban landscape and 'hedgehog-friendly' gardening practice are embodied in the *Hedgehog Street* public campaign by the PTES and the British Hedgehog Preservation Society (BHPS) (www.hedgehogstreet.org).

1.3 Hedgehogs in central London

In the early 1970s, hedgehogs were reported to be present in all London central Royal Parks (Simms, 1974); they have since disappeared from all central London sites except The Regent's Park. The reasons for the decline in central London's hedgehog populations are unknown, but the highly fragmented available habitat and isolation are likely to be very important factors as well as habitat quality. Isolated populations risk extinction from chance events such as bad weather or disease. A recent minimum viable population (MVP) analysis for hedgehogs (Moorhouse, 2013) suggested that urban habitats, presuming a relatively good supply of food/shelter and low predation risk, are likely to have an MVP of 32-60 individuals in a minimum area of 0.9-2.4km^2 (90-240ha) whereas rural areas, presumed to have a higher predation risk, would have an MVP of between 120-250 in a minimum area of 3.8-57km^2 (380-5700ha). Approximate total areas for the central Royal Parks (include lakes and built areas) are: The Regent's Park, 166ha; Primrose Hill, 25ha; Hyde Park, 140ha; Kensington Gardens, 111ha; St James's Park, 23.5ha; The Green Park, 19ha. The figures from the MVP analysis might suggest that The Regent's Park is the most likely site to have retained a viable population, but Hyde Park and Kensington Gardens (together 251ha) are separated only by West Carriage Drive which, although a busy route, is potentially permeable to hedgehogs.

The City of Westminster Biodiversity Action Plan (2007) features a Species Action Plan for hedgehogs for which The Royal Parks is a lead partner.

1.4 Hedgehogs in The Regent's Park

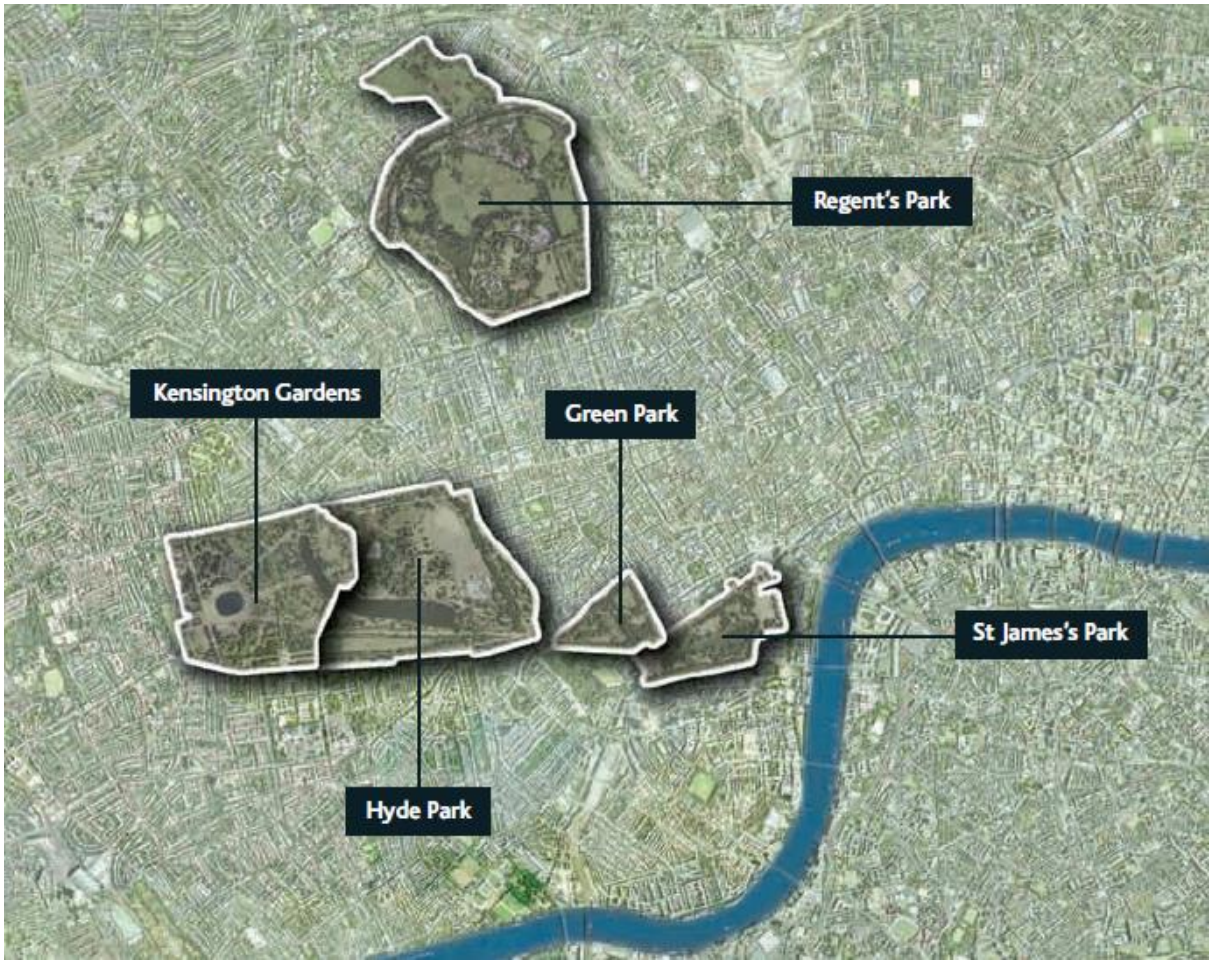


Figure 1.2 The Regent's Park in relation to the four other Royal Parks in Central London.

The Regent's Park is one of London's eight Royal Parks (plus a number of other sites) managed by The Royal Parks – a government agency of the Department of Culture Media and Sport (DCMS). The Royal Parks directly manage about 124ha of the site, with the remaining 42ha consisting of the Zoological Society of London (ZSL), Regent's University London, Winfield House, the Open Air Theatre and a number of private residences, including The Holme and St John's Lodge.

In terms of its habitats, The Regent's Park was formally surveyed in 2008 and again in 2012 for ground flora with habitats classified to the nearest National Vegetation Community (NVC) type (Land Use Consultants, 2013); see Appendix 2. A significant area of the park is devoted to intensively-managed sports pitches (including 10 full-sized football pitches and two full-sized rugby pitches, 4 cricket pitches and 18 softball pitches) and other amenity grassland (MG7 *Lolium perenne* leys) but otherwise the park offers an extremely diverse mixture of vegetation types including formal horticultural areas, shrubberies and less formal plantings, semi-natural grassland of various types and meadow areas, woodlands and hedges. Such a matrix of habitats would seem quite suitable as hedgehog habitat (see above) and the bow-top and other iron fencing used for the majority of boundary fences typically has vertical rods spaced widely enough for hedgehogs to squeeze through at ground level, allowing free movement.

In July 2011, footprint tunnels (*Anon*,2012) and nocturnal searching (spotlighting) were trialled by The Royal Parks staff in the Queen Mary's Gardens and Avenue Gardens areas of The Regent's Park over 6 nights (26-31 July 2011). Using 20 footprint tunnels, baited with a piece of hotdog sausage. 55% of the tunnels successfully detected hedgehogs (90% detected rats or mice). Six (spotlighting) walks were also conducted lasting 50 minutes each and yielded 31 sightings (4-6 per night) representing at least 6 individuals. In an undergraduate study (Olisah, 2014) replicating the 2011 footprint tunnel study in 2013, 40% of 20 tunnels detected hedgehogs.

Such preliminary work confirms the continuing presence of hedgehogs on the site, but it serves to emphasise the need to know more about the size and status of The Regent's Park hedgehog population and to discover more about the way in which hedgehogs currently use the Park. We know nothing of which areas are important for hedgehogs as nesting and foraging habitat, or whether hedgehogs may move outside the Park into the surrounding urban matrix of gardens, green spaces or the corridor of The Regent's Canal.

If the population is to be secure for the future, The Royal Parks will need information about the status of the current population and evidence-based advice to help manage the site more optimally for hedgehogs. In 2010, as a result of general concerns about the hedgehog population's isolation and vulnerability in The Regent's Park, and anecdotal reports that numbers may be diminishing, the Central Royal Parks Wildlife Group identified the need to resource a study of hedgehogs in The Regent's Park and produced a proposal upon which the present study has been based (Reeve, pers. comm.).

The present investigation will contribute to these objectives as well as serve both national and City of Westminster BAP objectives by providing information relevant to the management of urban habitat for hedgehogs, engage with the community and raise the profile of hedgehogs locally and nationally.

2. Aims of the Project

The principal aims of the project were:

1. To provide an estimate of the population size of hedgehogs in the Park in May and September 2014

2. To determine where hedgehogs can be found in the Park

3. To examine the ranging behaviour of a sample of adults to determine the extent of their movements and which habitats they use for foraging and nesting

4. To find out the extent to which the population is isolated within the Park or whether there may be viable links to nearby open spaces, such as Primrose Hill

5. Based on the findings, to develop a suite of habitat management recommendations to help conserve hedgehogs for managers of The Regent's Park and to provide a model that may be generalised to other urban open spaces

6. To engage volunteers, the local community and other stakeholders in the project

3. A Partnership Project

The Regent's Park Hedgehog Research Project was made possible thanks to a generous gift from The Meyer Family. This project was a very successful partnership between the following organisations and individuals.

Royal Parks Foundation is the charity that helps to support the magic of London's eight amazing Royal Parks. The charity reaches out to make the Parks part of more people's lives and raises funds for a wide variety of heritage, education, wellbeing and nature conservation programmes (registered charity 1097545). The charity delivers a wide ranging and accessible outdoor education programme at the Isis Education Centre in Hyde Park. The schools programme for primary and secondary schools is linked to the National Curriculum, and there is a year-round programme of informal activities for individuals and groups to join, from guided walks to hands-on sessions.

The charity acted as the Hedgehog Research Project lead and provided the management and resources required to coordinate and deliver the fieldwork; recruit, train and manage the volunteers.

The Royal Parks welcome almost 78 million Londoners and tourists each year. The 5,000 acres of historic parkland provide unparalleled opportunities for enjoyment, exploration and healthy living in the heart of London. London's eight Royal Parks are: Bushy Park, The Green Park, Greenwich Park, Hyde Park, Kensington Gardens, The Regent's Park and Primrose Hill, Richmond Park and St James's Park.

The Regent's Park and Ecology Teams worked particularly closely on this project, providing vital mapping and planning guidance as well as logistical and volunteer support during the fieldwork periods.

Zoological Society of London (ZSL), founded in 1826, is an international scientific, conservation and educational charity whose mission is to promote and achieve the worldwide conservation of animals and their habitats. Their mission is realised through their ground-breaking science, active conservation projects in more than 50 countries and two Zoos, ZSL London Zoo and ZSL Whipsnade Zoo.

ZSL provided vital veterinary support during the two weeks of fieldwork in May and September. The Horticulture Manager also kindly provided guidance, volunteer support and access to the zoo grounds which enabled this 15 ha of Regent's Park to be included in the survey.

Dr Nigel Reeve, BSc, PhD, PGCE, MCIEEM. Dr Nigel Reeve studied zoology for his BSc and obtained his PhD by researching hedgehog ecology; both at Royal Holloway College, University of London. Having completed a PGCE at Garnett College (London), from 1982 to 2002 he taught and researched at Roehampton University and in 1994 published a monograph Hedgehogs in the Poyser Natural History series. From 2002 to 2013 he worked as Head of Ecology for The Royal Parks.

Nigel Reeve has provided invaluable expert guidance in the planning, delivery, training, fieldwork and interpretation of the results of this hedgehog research project. He is a co-author of this report.

Professor John Gurnell, BSc, PhD. Emeritus Professor of Ecology, Queen Mary University of London. John Gurnell has carried out research on the ecology, behaviour, genetics, management

and conservation of mammals, including methods of study, data analyses and modelling. He is especially interested in forest management, reintroductions and translocations as conservation tactics, modelling mammals in relation to management and disease, and the health and welfare of wild and captive animals.

John Gurnell has provided invaluable expert guidance in the planning, delivery, training, fieldwork and data analysis of this hedgehog research project. He is a co-author of this report.

People's Trust for Endangered Species (PTES) is a UK conservation charity created in 1977 to ensure a future for endangered species throughout the world. Working to protect some of the most threatened wildlife species and habitats; it provides practical conservation support through research, grant-aid and educational programmes, including wildlife surveys, publications and public events. PTES, in partnership with BHPS, run an awareness campaign called Hedgehog Street aimed at ensuring the hedgehog remains a common and familiar part of British life. PTES and BHPS are also funding a National Hedgehog Survey using footprint tunnels.

PTES provided expert guidance with regards to footprint tunnel work and footprint recognition.

Central Royal Parks Wildlife Group brings together amateur and professional naturalists and ecologists who share an interest in the range of wildlife which survives within the Central Royal Parks, and promotes wildlife-friendly management alongside other priorities for the parks.

The Group originally identified the need for a hedgehog survey in The Regent's Park and subsequently provided guidance and volunteer support in the field.

Untyped All data for this project was collected and hosted on Cartographer (http://cartographer.io), a cloud-hosted service for crowd-sourcing environmental data. Cartographer allows environmental groups to collect data from volunteers and display it using custom maps and charts. The software has been developed by Untyped (http://untyped.com), who kindly provided the project with custom set up and support.

The volunteers The fieldwork was supported by a team of 68 fantastic volunteers consisting of individuals with a wide range of backgrounds but a keen interest in wildlife and conservation.

A Regent's Park Hedgehog Research Management Team was formed involving representatives from each organisation which met every two months or so to review progress and discuss plans.

4. Survey Design

4.1 A science-led, community-based research project

This project was carried out under licence from natural England; licence number 2014/SCI/0402

Five complementary survey methods were adopted to help gather as much information as possible about the hedgehog population in The Regent's Park and produce different levels of detail about their ecology and behaviour.

This approach involved a very resource-intensive programme of fieldwork which relied on the recruitment of a dedicated volunteer team.

The survey methods included:

1. Footprint tunnels - systematically placed throughout the Park to assess broad patterns of distribution.

2. Spotlighting - surveyors systematically searched for hedgehogs throughout the park for 2-3 hours after dusk on specific days to detect hedgehogs and hand capture, mark and release selected individuals.

3. GPS tracking - GPS packs were fitted to selected hedgehogs to get a broad picture of habitat use over a week.

4. Radio tracking – VHF radio tags were also fitted to these selected hedgehogs and, using radio receivers and aerials, were located and followed over periods of 3-6 nights to assess foraging and feeding movements.

5. Camera trapping – camera traps were set up at specific locations to remotely record the presence and behaviour of hedgehogs.

Recordings forms for each survey method were created for the May project and edited slightly for the September survey. The September forms can be found in Appendix 4.

Further details of the methods are presented below and an equipment list is included in Appendix 1.

4.2 Division of The Regent's Park into Survey Zones

Regent's Park covers 160ha. In order to conduct a systematic search of the entire park, the project management team divided the park into seven zones based on the intimate knowledge of the Park managers and wildlife officers.

Primrose Hill was deemed to be outside the scope of this pilot study in 2014. There had been no incidental sightings of hedgehogs in that area in recent years and there are no obvious safe routes between Regent's Park and Primrose Hill across the busy main road.

Areas of the park not managed by the Regent's Park team include Winfield House, Regent's University London, The Holme, Capel Manor College and St John's Lodge. These areas were out of bounds for the fieldwork. However, privileged access was given by Winfield House for one night on 1st June.

The Project Team was based at the Old Ironworks buildings, just on the Inner Circle. This became the 'Hedgehog Headquarters' and provided a safe place to meet, greet and train volunteers and for equipment to be stored.

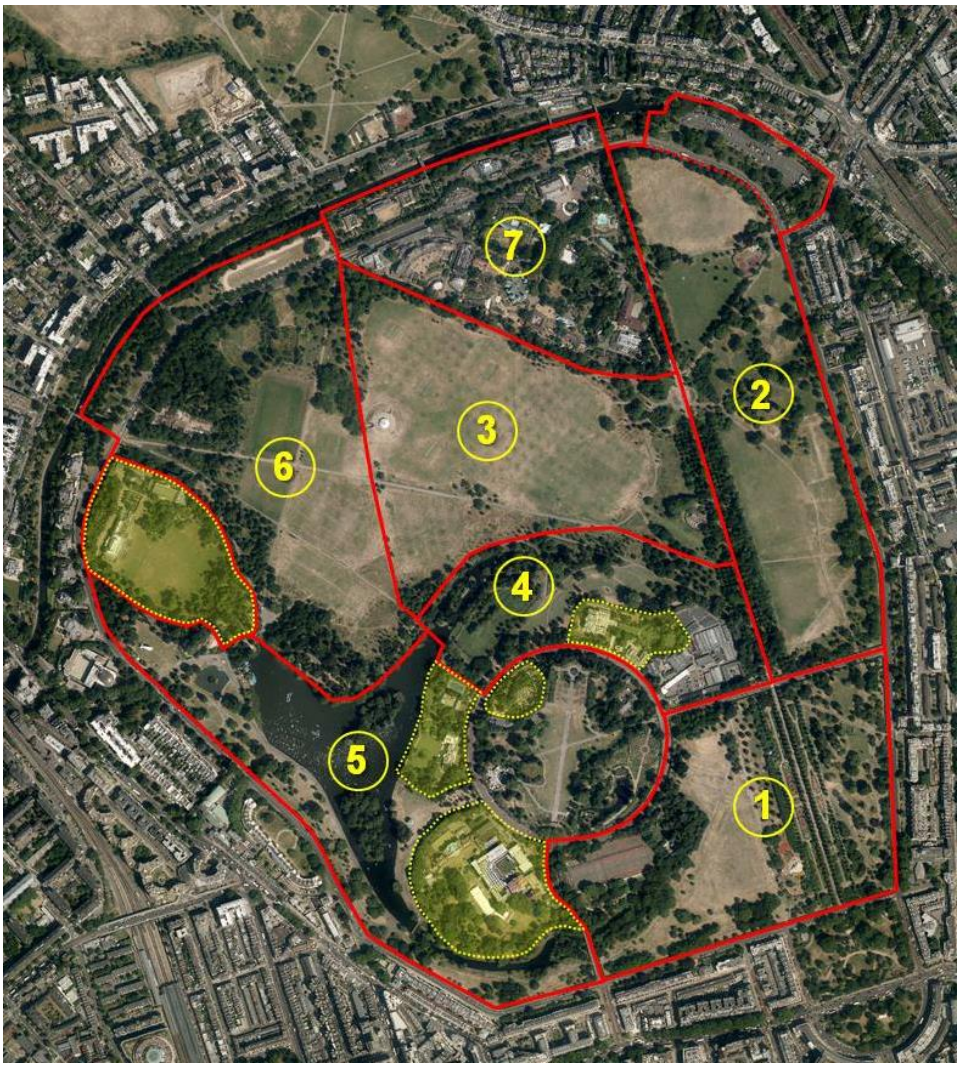


Figure 4.1 Aerial view of Regent's Park showing the boundaries of the seven survey zones and the five inaccessible areas (dotted line and shaded yellow)

4.3 Survey timings

Two intensive periods of fieldwork took place:

- 19 – 31 May 2014 - after the hedgehogs had woken up from hibernation and become sexually active.
- 5 –15 September 2014 - after breeding and prior to hibernation when both sexes were still active. Any young would be from this year and litters would not be disturbed in their nests.

4.4 Volunteer involvement

A team of volunteers were recruited to carry out all the five different survey methods. These volunteers worked alongside the project team supervisors to complete all required activities on each survey day and record the data captured.

The volunteers were key to the fieldwork's success and together with the project supervisors worked a total of 1,165 hours (146 8-hour days) over the May and September survey periods (Table 4.1)

Month	Activity	Volunteer hours in the field	Supervisor hours in the field
May	Footprint Tunnels	129	36
	Spotlighting	248	77
	Radio Tracking	180	68
	Camera Trapping	27	7
	Total	584 hours (73 days)	187 hours (23 days)
September	Spotlighting	215	80
	Radio Tracking	158	51
	Camera Traps & FT	20	10
	Total	253 hours (32 days)	141 hours (18 days)
May + September	**Total**	**836.5 hours (105 days)**	**328 hours (41 days)**

Table 4.1 Volunteer and supervisor hours worked on the hedgehog survey in May and September 2014

4.4.1 Volunteer recruitment, management and retention

In order to capture people's imagination and motivate the team, the volunteers were branded as 'Hedgehog Heroes'. A volunteer recruitment pack was produced and shared by email to groups known to the Foundation and other recommended contacts. Interested volunteers then submitted application forms by email to the Royal Parks Foundation Volunteer Manager who liaised with them closely throughout the project.

Volunteers were recruited from a number of sources – 53 in May and 43 in September (Table 4.2):

Month	Source of volunteers	Number
May	'Hedgehog Street' (via PTES and BHPS)	13
	Local corporate supporter	8
	Other enthusiastic Royal Parks & Foundation team members	9
	Word of mouth	16
	ZSL MSc Students	4
	Project Dirt website	3
September	Repeat volunteers from May	(28)
	Arup (via Central Royal Parks Wildlife Group):	6
	Word of mouth	9
Total		**68**

Table 4.2 Recruitment sources of the 68 volunteers

NB. Fewer volunteers were needed for the September survey as there were fewer survey days and not as many footprint tunnels to manage.

The Volunteer Manager kept in close contact with the volunteers throughout the project. They:

- received regular email updates
- had the opportunity to attend a training workshop
- were involved in real life scientific research project
- had the opportunity to handle a hedgehog
- were provided with refreshments during the survey nights
- were invited to a thank you BBQ at the end of the project in Regent's Park
- received certificates of participation & references
- received a thank you gift at the end of the project
- were given the opportunity to buy a specially-designed range of 'Hedgehog Hero' clothing

The feedback from the volunteers was excellent and the project fostered a real sense of community and willingness to stay involved in other wildlife research projects in the Parks.

"Thank you all for giving me the opportunity to do this hedgehog survey. I really enjoyed it. A definite highlight of my year! Please do keep me in mind for any other nature related volunteers you may need." – Mary O'Neill, project volunteer

4.4.2 Volunteer training

In order to promote best practice in the field, to ensure that the hedgehogs' welfare was a priority at all times and foster a good team spirit, two volunteer training sessions were held in Regent's Park led by the project team and our expert scientific advisors.

The aims of these sessions were to:

- Brief the volunteers on the research programme as a whole.
- Introduce the core project team and partners.
- Demonstrate the techniques and equipment volunteers would use in the field and allow time for practice.
- Outline the welfare facilities available and run through the risk assessment.
- Say thank you to all the volunteers.
- Build a sense of common purpose and team spirit.

Two training session options were offered to the volunteers ahead of the May survey. As there were so many repeat volunteers in September, only one session needed to be held. They were held at the Old Ironworks Buildings in Regent's Park on the following dates:

Saturday 10 May: 10:00 – 13:15

Wednesday 14 May: 17:30 – 20:30

Wednesday 3 September: 17:30 – 20:30

A comprehensive volunteer survey guide was produced for each survey period (see Appendix 3). The main contents of this pack were:

1. Project Summary
2. About hedgehogs
3. Survey activities overview
4. Key dates
5. Survey Zone Maps
6. How to handle a hedgehog
7. Hedgehog marking system
8. Hedgehog first aid
9. Data Management
10. Volunteer kit list
11. Risk assessment
12. Hedgehog HQ
13. Emergency Procedure
14. Travel
15. Key Contact Details
16. Project Partners
17. How-to-guides

These survey guides were distributed to the volunteers at the training sessions as part of their volunteer 'pack' along with a field notebook, pen, pencil, rubber and a lanyard with key contact information.

When volunteers arrived at the training session they were also asked to sign a medical release form and a photograph and film footage release form.

Feedback from the volunteers about the training days was excellent:

"Super excited for the surveys", "Surpassed my expectations", "Thanks for the incredible opportunity"

"I really really enjoyed every minute of it, FAB! Highlights - expert knowledge, enthusiasm, clarity, friendliness, creativity, seeing hedgehogs"

Figure 4.2 Volunteers learn to prepare footprint tunnels

Figure 4.3 Volunteers learn how to use a radio receiver to detect tagged hedgehogs

4.5 Personnel Health and Safety

Volunteers' health and safety was of paramount importance to the programme and a risk assessment was produced by the Royal Parks Foundation, signed off by the Park Manager and distributed to the volunteers within their volunteer pack (see Appendix 5) at the training sessions. A number of measures were put in place to reduce the main risks involved:

1. Volunteers would always work in a minimum group size of 2 so they were never alone in the Park

2. A project supervisor from the core team was always on site in Regent's Park when volunteers were there

3. Hi-vis jackets were provided for volunteers to wear so they could be easily seen within the Park

4. At night time, individual LED torches were provided to each volunteer for use when walking around the Park

5. Personal lanyards, which had a card with the projects key contact Information including the Regent's Park Duty Sergeant and the emergency procedure, were given to each volunteer

6. Gloves and goggles were provided for handling hedgehogs

7. Hand sanitiser was provided for after handling hedgehogs

8. All equipment was checked regularly and well maintained, any broken equipment disposed of

9. When night time shifts ended after the last tube, volunteers who didn't have access to their own transport were provided with a taxi home

10. Spare warm clothing was kept at Hedgehog HQ

The Parks police were informed of the survey dates so knew volunteers would be on site after the Park had closed. An emergency procedure was also put in place and outlined in the volunteer briefing pack.

4.6 Veterinary support from ZSL

The Veterinary Services at ZSL, as key partners to the project, were on standby during both periods of fieldwork in May and September.

The welfare of animals was deemed paramount at all times.

A veterinary surgeon or veterinary nurse was 'on duty in the field' on the spotlighting nights in case any hedgehogs were found to be visibly unwell or injured. The animals would be taken to the ZSL hospital where all necessary care would be provided.

On the other survey nights, if any surveyor were to come across an injured animal, it was agreed with the emergency veterinary practice at Elizabeth Street in Victoria that they would be able to accept any hedgehog which needed attention.

If hedgehogs were found during the day, the veterinary team at London Zoo were on standby to help.

4.7 Data management

Data were recorded by hand in the field using template recording sheets for each survey method. All the data were then collated on two online platforms: Cartographer and Dropbox. Both these platforms were accessible to all volunteers and stakeholders to submit and view data.

4.7.1 Cartographer

Cartographer is a field data management system for environmental groups. This software is well suited for managing crowdsourcing data collection activities such as the Hedgehog Research Project. A bespoke Cartographer web application was created, capable of collecting, storing, processing, and displaying all the data from the hedgehog project.

Four survey forms were created for each of the four survey types (footprint tunnels, spotlighting, camera trapping and Radio tracking). Each form contained appropriate fields to enter all the necessary data, guidance to help volunteers enter everything correctly, and appropriate facilities to upload photographs and scanned images.

To help ensure data quality, once a volunteer had completed the online entry of a data sheet, the project team had the ability to edit and approve it, preventing any further changes. Approved data could then be displayed on an interactive map. All data could easily be downloaded by the supervisors in Excel, CSV, and Shapefile formats.

There were two types of user:
1. Volunteers - could submit surveys, browse individual survey forms, and view the park map;
2. Administrators – could approve surveys, download data, and manage user profiles.

All volunteers were given access to Cartographer so they could see the data after it had been added although only supervisors could edit the data. The database could be accessed from the Royal Parks Foundation website, using a dedicated username and password.

4.7.2 Dropbox

Dropbox is an online service that allows the sharing of files, photos and videos. It was used in this study for gathering photos and videos taken in the field by volunteers.

All volunteers were given access to Dropbox to share their fieldwork photographs and videos. Detailed instructions on how to view data collected and stored in Dropbox were sent to all volunteers before the survey started.

Supervisors added data from the GPS tracking and camera traps to Dropbox in a separate folder, not shared with the volunteers.

4.8 Data analyses

The position of study zones and location of hedgehogs as determined by direct search (spotlighting), Radio tracking and GPS tracking have been presented on Google Earth maps. Survey data recorded on Cartographer have been analysed with Excel, Xlstat and Minitab software. Movement, home range size and habitat analysis have been carried out using Ranges 9 (Anatrak Ltd.). As a result of small sample sizes and a lack of normality, non-parametric tests were used to analyse the data. In particular, Mann-Whitney tests have been used to compare two samples and Spearman's rank correlation coefficient (r_s) for tests of association between two variables.

4.8.1 Home range analysis

GPS tags can produce a large volume of data but GPS locations are subject to variation in accuracy and precision (Frair *et al.*, 2010).This has been considered in detail in Appendix 6, together with how obvious rogue locations were filtered out.

The GPS data for each animal were analysed according to night-time (21:00 to 06:00 hours) when animals were likely to be active and daytime (06.00 to 21.00) when, for much of the time, the animals were likely to have been in their nests. Movement and home range have been analysed with particular respect to night-time activity, although day range areas and the centres of the day range areas have also been calculated. The distance moved each night by an individual has been estimated by summing inter-fix distances (m) from first to last fix. The home range of an animal is the area over which it moves in carrying out its normal daily activities of foraging, mating and caring for young (Burt, 1943) and there are several ways of estimating home range areas from a set of locations. Two popular techniques have been used here for direct comparison with the literature, 100% and 95% (i.e. excluding 5% of the outermost locations) simple minimum convex polygons (MCP) and 95% probabilistic kernel methods (e.g. Worton, 1989; Wauters *et al.*, 2007). The MCP method measures the home range area as that bounded by the smallest convex polygon that contains all locations. Kernel methods assume that an individual uses space as described by a bivariate probability density function, called the utilisation distribution (a three dimensional probability map with the vertical axis representing which parts of the home range are used most frequently). The area bounded by the 95% isopleth (contour) gives the 95% probability of finding (locating) the animal within that area (Figure 4.4). Home range areas have been presented in hectares.

(a) 95% Minimum Convex Polygon home range area (1.5 ha)

(b) 95% kernel home range area (1.4 ha)

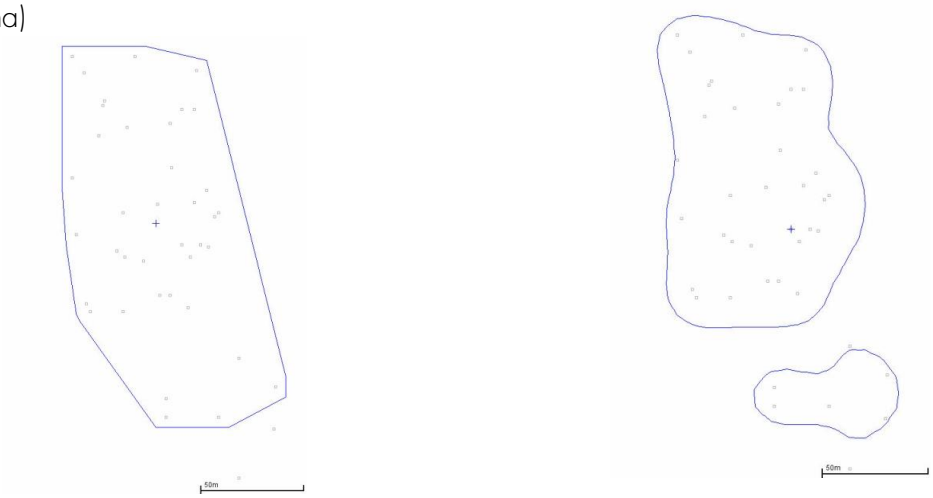


Figure 4.4 Examples of home range area estimates using 95% minimum convex polygon and 95% kernel methods using dummy data. The + symbols represent home range centres.

4.8.2 Habitat analysis

A habitat map of The Regent's Park (supplied by The Royal Parks in the form of an ESRI shapefile), was imported into Ranges 9 and used to analyse which habitat types were used by individual GPS-tagged hedgehogs. There were 13 habitat categories in the habitat map: planted shrubberies and flower beds, ruderals, tall herbs, improved neutral/acid grassland, roughland, semi-improved neutral grassland, woodland, hedgerow, reedbeds and marginals, open water, bare artificial habitat, amenity grassland, and areas not surveyed. The analysis involved estimating the habitat at each GPS fix with a 5 m radius buffer for each hedgehog, and from these data, the relative composition of habitats used by the hedgehog was calculated. However, to understand whether a hedgehog was selecting or avoiding particular habitats within their home ranges, the availability of each habitat type within an individual's home range was estimated from the 95% MCP home range of each individual. The proportions of habitats used by and available to each animal have been compared using Jacobs Index, D (Jacobs, 1974). D is calculated as follows:

$$D = \frac{(r - p)}{(r + p - 2rp}$$

where r is the proportion of habitat used and p the proportion of habitat available. D varies from -1 (strong avoidance) to +1 (strong preference); values close to zero indicate that the habitat is used in proportion to its availability. Ruderals did not occur in any ranges and location data in areas where the habitat had not been surveyed were left out of the analysis.

5. Survey Methods

5.1 Spotlighting

Spotlighting consisted of systematic nocturnal searches (using designated routes) within seven selected zones of the park and within ZSL (Figure 4.1) to locate hedgehogs with the aid of bright torches (LED Lenser P7.2, brightness up to 320 Lumens). Searching also involved listening for the rustles in undergrowth, or the noises made during courtship or fighting. As hedgehogs 'freeze' when they hear the sounds of a potential predator approaching, fieldworkers were instructed to minimise conversation, walk quietly on grass or bound surfaces where possible and wear rustle-free clothing.

On the two main Friday survey nights in May and September. Teams of 4-5 volunteers plus one supervisor were sent to each zone and given a set route to walk around. The volunteer tasks involved:

- Searching for the hedgehogs
- Recording the data captured for any hedgehog found on a pro forma
- Assisting the supervisor with weighing, checking and marking the hedgehog
- Taking photographs of the group or hedgehogs found

The protocol was for groups to spread out but to follow the route at a steady slow rate, pausing briefly every 20 metres or so to listen for sounds. Walking closely to the edges of hedges or borders allowed the searchers to listen for sounds in the undergrowth whilst also scanning the torch across open grassland where hedgehogs were easy to spot. Location records from spotlight searches will inevitably be biased towards open habitats. Experienced searchers will also find hedgehogs in undergrowth but will be less effective where there is background noise such as that from wind or traffic or when walking on noisy surfaces.

Spotlighting is a simple, effective and low disturbance way to locate hedgehogs for identification marking, gathering biometric data and attaching VHF or GPS tags. Data were recorded on the Spotlighting Data Recording Form (Appendix 4a).

Identification marking was carried out using a system of marking the spines with colour combinations of 5-10mm lengths of coloured plastic electrical sleeving (Polyolefin cable sleeve) glued over 5 individual spines in each of one or more areas of the dorsal pelage. For the marking scheme please see pages 11 & 12 of the Volunteer Survey Guide in Appendix 3. The plastic sleeving was filled with glue and fitted over the spine leaving the sharp tip protruding; so the spine remains fully functional (Figure 5.1). Such marks last longer and are more visible than paint but are not permanent and will eventually moult away. However, as spines can have a life of up to 18months (Reeve, 1994) it was judged that marks would certainly last for the duration of each sampling period and likely that at least one colour marker per patch would remain for the period of slightly over 3 months between the end of May and early September

Using individual identification marks allowed population size to be estimated as well as persistence in the population between the first and second survey periods.

Figure 5.1 Hedgehog 13, a subadult male (600g) found on 5/09/2014 with coloured plastic markers glued on to spines in positions A (crown of head) and C (right shoulder)

5.2 Footprint tunnels

5.2.1 May

Sixty five footprint tunnels were positioned in the Park and London Zoo grounds following recommended guidelines from the PTES National Hedgehog Survey protocol. Tunnels were placed allowing a minimum of 100 metres space from each other, following linear features where possible and in areas where natural animal paths could occur (Figures 5.5, 5.6).

Each tunnel was numbered, pegs were used to secure the tunnel to the ground and as they were placed in a public park, each tunnel had a sign alerting the public that it was part of a scientific survey and so not to disturb it. Chopped tinned hot dog sausages were used as bait (Figure 5.2).

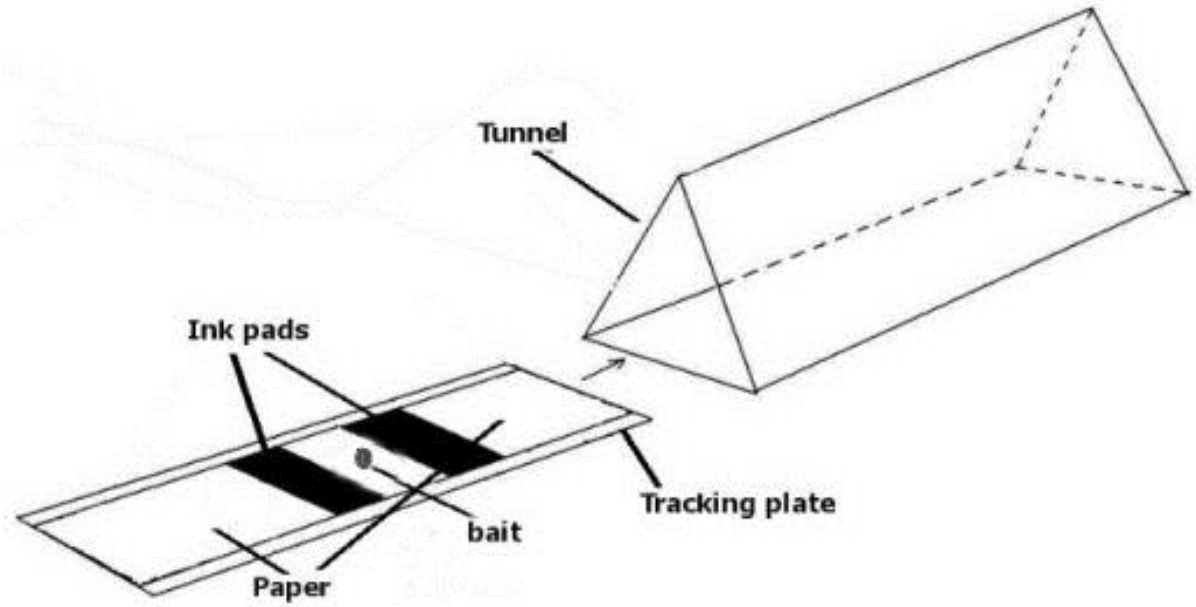


Figure 5.2 Schematic diagram of the footprint tunnels (Source: National Hedgehog Survey Volunteer Handbook, 2014)

An average of eight tunnels were placed in each of the seven survey zones, except for Zone 4 where only four tunnels were placed, the other four were placed inside the border of Zone 3. All 65 tunnels were in place for a period of 4 nights, from Monday 19 to Friday 23 May.

Three teams of 3-4 volunteers checked the tunnels daily and replaced the two papers, regardless of whether there was evidence of footprints. The bait was also replaced, ink replenished and any disturbance dealt with. It was agreed that if a hedgehog footprint was found then the tunnel would be moved to a new location within the zone.

The completed pro formas and footprint papers were collated by a supervisor and uploaded to Cartographer. A sample form can be found in Appendix 4c.

5.2.2 September

As the May footprint tunnels did not yield any hedgehog footprints at all, only eight tunnels were strategically placed in the park in September, in conjunction with eight camera traps.

This meant that fewer volunteers were needed to check the tunnels as they could be checked daily at the same time as the camera traps.

Figure 5.3 Volunteers checking the footprint tunnels

Figure 5.4 Example of a footprint tunnel in location

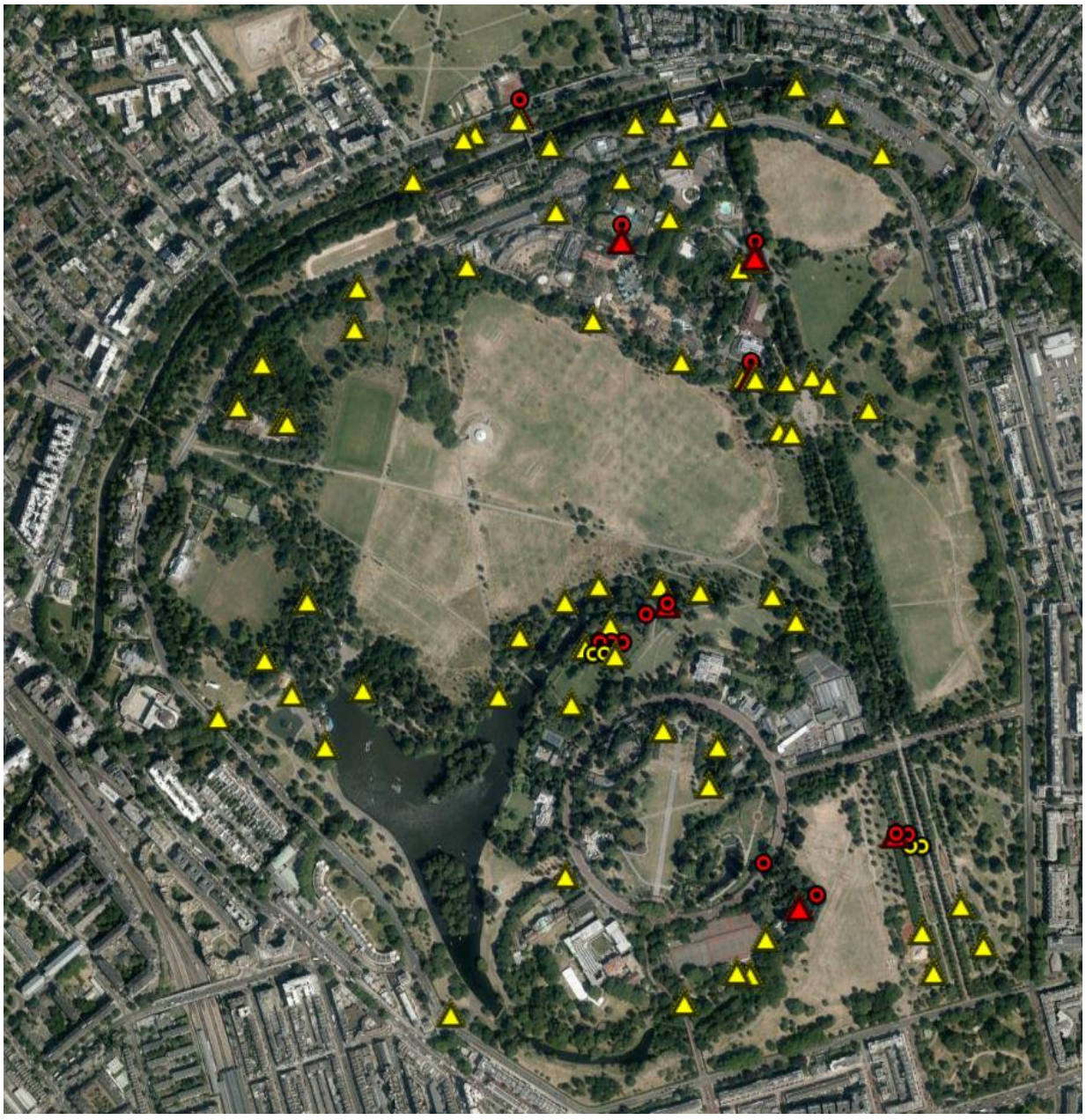
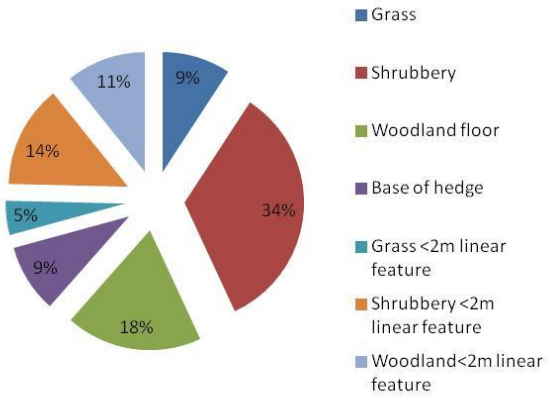


Figure 5.5 Position of footprint tunnels (triangles) and cameras (circles) in May (yellow symbols) and position of cameras + tunnels in September (red symbols)

(a) May



(b) September

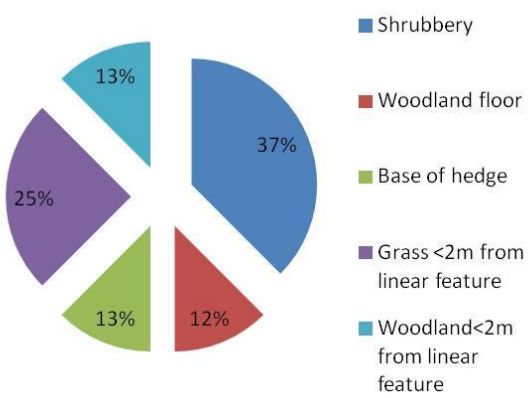


Figure 5.6 Habitat in which footprint tunnels were placed in (a) May (48 tunnel placements) and (b) September (8 tunnel placements).

5.3 Camera traps

The cameras used in this survey were Bushnell HD Trophy Camera. They were triggered by movement and set to record for 10 – 20 seconds, day or night.

5.3.1 May

Ten cameras were positioned in seven locations in the park, none in London Zoo grounds.

The location of the cameras was carefully considered as it was important to minimise the risk of these high value items being stolen or tampered with whilst also choosing suitable habitats that hedgehogs may use (Figure 5.7). As such, the cameras were positioned in secure areas of the Park managed for wildlife and not accessible to the general public. The cameras themselves had padlocks placed on them which had to be opened to switch the memory cards. The cameras were set to record for 10 seconds in May. Three of the locations had two cameras positioned together to capture the footprint tunnels at some different angles.

Footprint tunnels were used at each location to attract hedgehogs and were checked daily alongside the cameras.

The cameras were in place for seven nights. 2-4 volunteers checked the cameras daily at lunch time, replaced the memory cards and ensured the cameras were still working and hadn't been disturbed.

Any data on the retrieved memory cards were then downloaded to a hard drive and viewed by a project supervisor to scan for hedgehog footage.

Figure 5.7 May camera trap locations

5.3.2 September

Due to the low hedgehog detection rate in May, it was decided to focus on four key locations and place two cameras at each location. Eight cameras were placed in the field in total in areas safe from possible public interference (Figure 5.8).

Two locations were identified within the Wetland Pen in Zone 4. Two new locations were also identified in Zone 1, along the fence line and within the grounds of Hedgehog HQ where hedgehogs were known to nest. As in May, footprint tunnels were positioned next to each camera to encourage hedgehogs to the area. The cameras were set to record for 20 seconds.

The cameras were in place for 5 nights. Two volunteers plus one supervisor checked the cameras daily in the early evening, replaced the memory cards and ensured the cameras were still working and hadn't been disturbed. The cards were then checked by a project supervisor and any recordings were downloaded to a hard drive and uploaded to Dropbox.

ZSL also positioned four cameras in Zone 7, London Zoo, for 10 days from 19-30 September. These were not baited but directed at likely paths that hedgehogs might use.

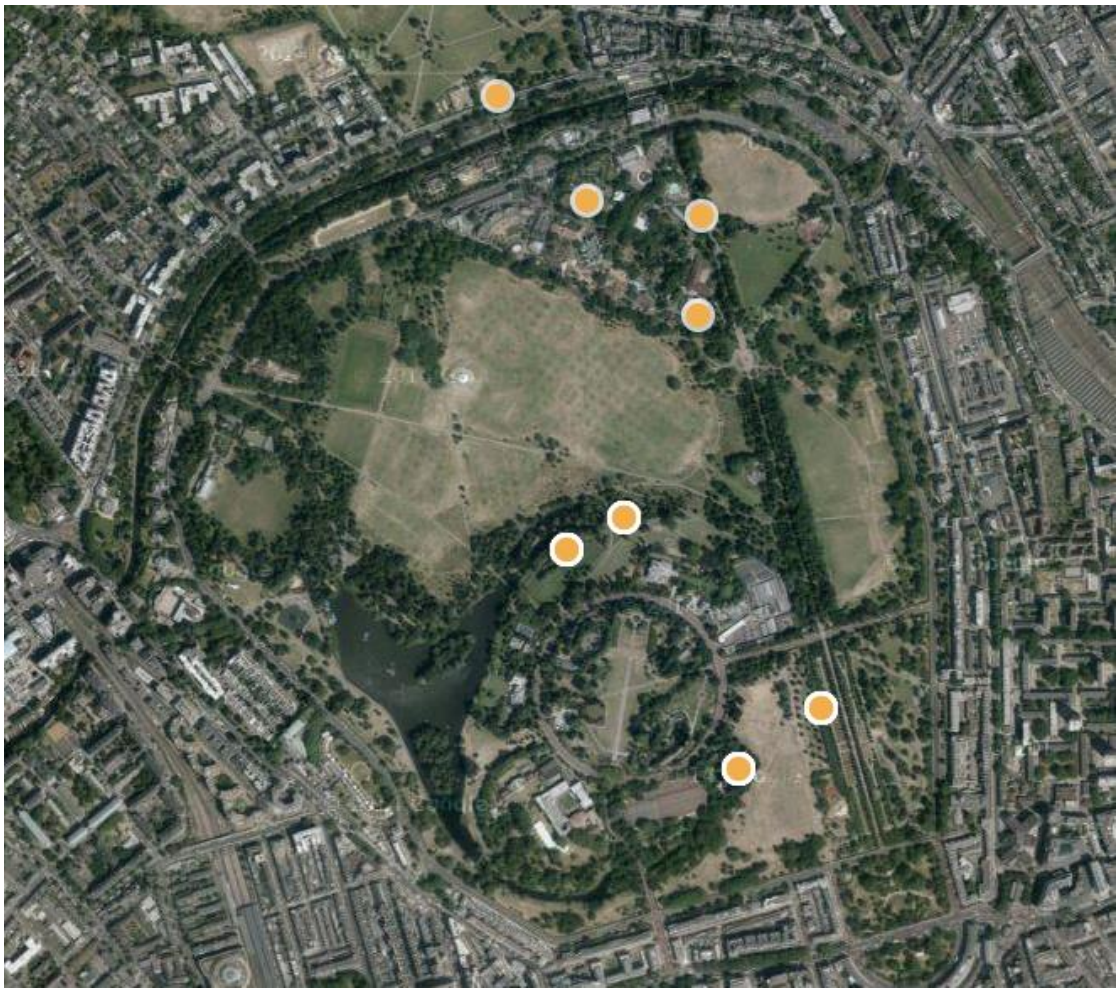


Figure 5.8 September camera trap locations

5.4 Radio tracking

VHF radio tags (Biotrack TW-5, 173MHz, weight 13g: Biotrack Ltd. Wareham Dorset U.K.) were attached to 6 hedgehogs (4 males, 2 females) in May and 10 in September (2 males, 8 females). Animals were relocated using either a Sika, TRX or Mariner receiver with a handheld 3-element Yagi aerial.

Radio tracking was used to relocate hedgehogs as required to retrieve GPS tags (see below), to precisely locate nest sites and for behavioural observation of selected animals (recording form in Appendix 4b). Radio tracking is the only method that allows individuals to be regularly monitored and their nest sites, foraging areas and interactions with conspecifics to be observed.

Volunteer support for radio tracking comprised of 6-9 volunteers available each night. Depending on the focus for the night and the location of the hedgehogs being followed, the volunteers and two supervisors would search for the animals. Once a hedgehog was found, two volunteers were left with the hedgehog to record its behaviour as the rest of the group moved on to find the next hedgehog. If the hedgehogs we wanted to track were in different areas of the Park, the volunteers would be split into two groups, each with a supervisor. Again, if a hedgehog was found, two volunteers would remain with the hedgehog whilst the others moved on to find the next hedgehog.

Whilst members of the group were locating the radio signals, the other volunteer members would take the opportunity to carry on spotlighting the Park to discover new, unmarked hedgehogs.

VHF transmitters were glued to the mid-dorsal spines by using clippers to cut short an area of spines – leaving them about a third of their original length – in a patch corresponding to the size of the transmitter. A fast-setting epoxy adhesive (Araldite 90 seconds) was then applied to the base and sides of the transmitter which was positioned onto the cut patch and held for at least 90 seconds. The glue bonded to the cut spines and also to adjacent uncut spines as shown in Figure 5.9 and 5.10. At the end of the study the transmitter was removed by trimming away the spines to which the transmitter was glued.

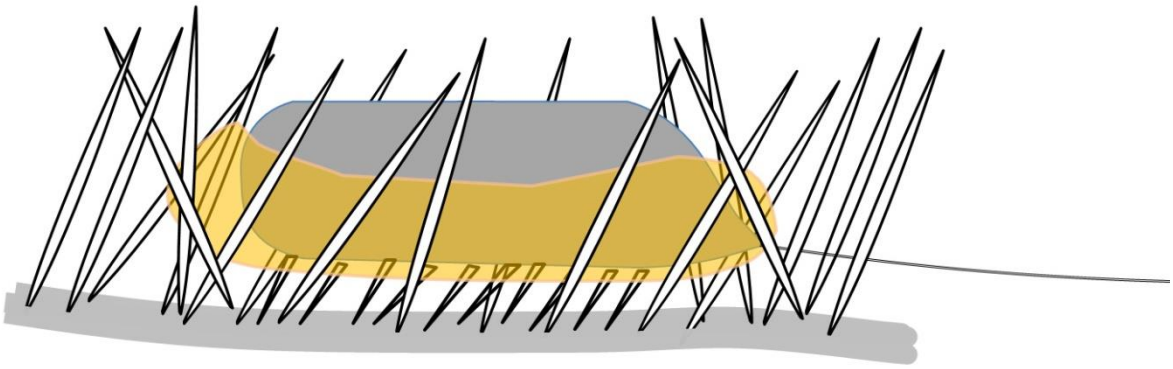


Figure 5.9 Diagram showing how the transmitter package is glued to the dorsal spines

Figure 5.10 A hedgehog with VHF transmitter and GPS tag glued to the dorsal spines.

5.5 GPS tags

The GPS tags used were I-gotU travel trackers (A41JF, Maplin, U.K.) modified by Mark Ferryman as described by Stevenson *et al.* (2013) (Figure 5.11). The modified tags weighed approximately 18g and were 42mm x 24mm x 10mm. Attachment to the study animals followed the same protocol as transmitter attachment (see above). We carried out static tests on 10 GPS tags at Hyde Park to determine fix accuracy and found them to be accurate overall to within 10 metres in open areas (See Appendix 6 for more details).

Six animals were tagged for seven nights in May and 10 animals tagged for seven nights in September.

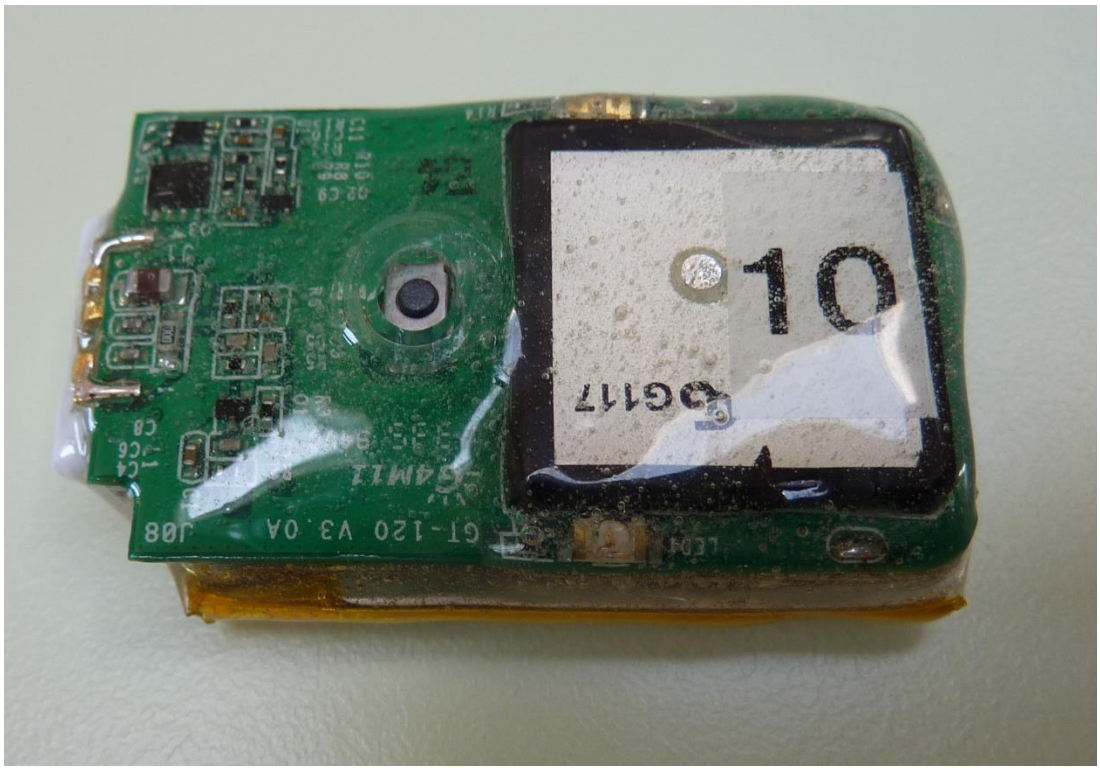


Figure 5.11 GPS tag for use on the hedgehogs of Regent's Park

6. Results

6.1 Hedgehog numbers

Twenty-seven hedgehogs were captured in May and 41 in September (Appendix 7a). The Zoo car park in the north-east of The Regent's Park was not surveyed in May but was in September when 11 individual hedgehogs were captured. Thus, 30 animals were captured in the rest of the Park in September, only slightly more than the numbers in May.

The sexes of one hedgehog in May and three in September were not determined. Male adults on average weighed 930 g and females 950 g in May; males 1000 g and females 975 g in September (Table 6.1). Three lightweight animals were captured in May which and been classified as subadults. In September there was evidence of summer breeding with 10 subadults and four juveniles captured. Overall, there was a reasonable association between body weight and body circumference (r_s = 0.78, P<0.001, N = 69), although this varied slightly according to survey month and sex (Appendix 7b). An approximately equal number of adult males and females were captured in May (sex ratio, female: male, = 1.1), but relatively more adult females were captured in September (sex ratio = 1.7) (Table 6.1).

Excluding the hedgehogs that died in May, 69% of the female hedgehogs captured in May were recaptured in September, but males fared less well with only 38% being recaptured (Figure 6.1).In addition, and not including the Zoo car park, three new (unmarked) adult females were captured in September.

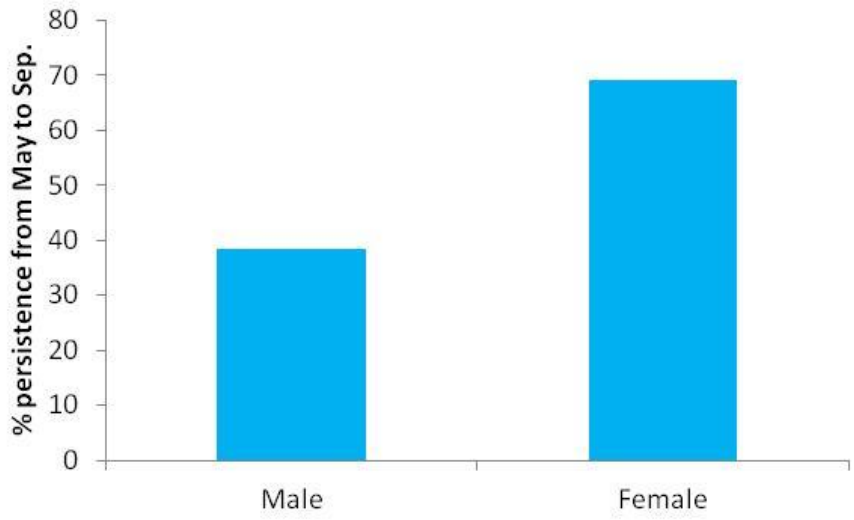


Figure 6.1 The percentage persistence of animals marked in May recaptured in September (termed persistence from May to September because it is not known whether animals survived but were not recaptured in September).

Most hedgehogs were captured in Zones 1 and 5 in May, with few captures in Zones 2 and 6, very few captures in Zones 3 and 4 and no captures in the Zoo grounds (Appendix 7a, 7c, 7d, 7e) In September, the pattern was similar but the importance of the Zoo car park as a focus of hedgehog activity can be seen in Figure 6.2 and Table 6.2. Thus, overall the best areas of the Park for hedgehogs were Zone 1, Zone 2 - the Zoo car park - and Zone 5; the worst area was the playing fields and Zone 3. Zones 2 (excluding the Zoo car park), 4 and 6 showed less hedgehog activity than might be expected based on our judgement of apparent habitat suitability.

			Weight (g)		
Month	Age	Sex	N	Mean	Stand Dev
May	Adult	Female	12	950.4	179.80
		Male	11	931.8	148.18
	Subadult	Female	1	661.0	-
		Male	2	625.0	106.07
September	Adult	Female	15	975.3	170.1
		Male	9	1000.0	164.3
	Subadult	Female	4	567.5	33.0
		Male	6	511.7	136.9
	Juvenile	Female	3	203.3	5.8
		Male	1	220.0	-

Table 6.1 The mean weights with standard deviations of individual hedgehogs grouped according to age, sex and month. Where animals were recaptured and re-weighed, a mean weight for each individual was used to calculate the group mean.

In May, spotlighting surveys were only carried out on the first and second Fridays. In September these were carried out on the first Friday and Saturday and the second Friday. Hedgehogs were also captured throughout each survey week during the course of radio tracking tagged animals. (Figure 6.4). By the second Friday survey night, 89% of the hedgehogs in May and 88% in September were recaptured animals. Most animals were captured in the first two hours of field work, which normally started between 20:30 and 21:00 hours (Figure 6.5). Captures tailed away after 23.00 hours; field work generally stopped between 23:30 and 00:30 hours.

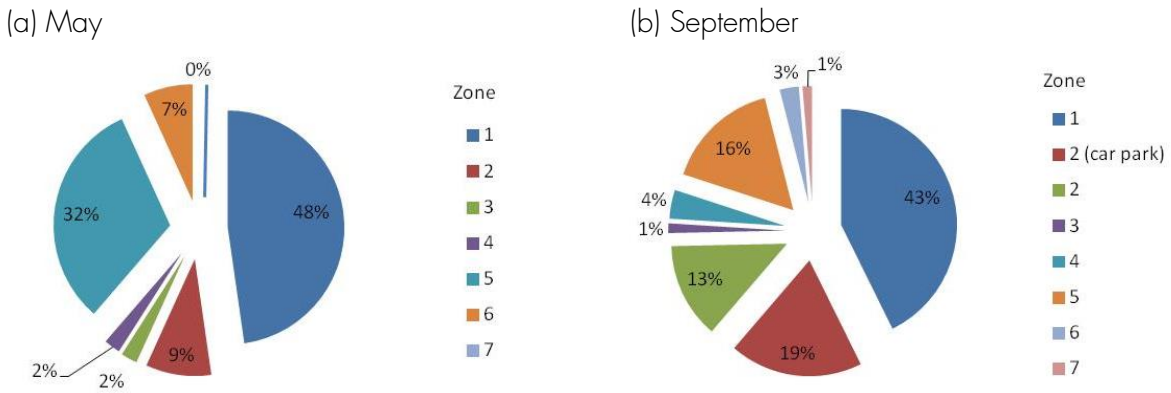


Figure 6.2 Proportion of hedgehog captures (new plus recapture) in each zone in (a) May (N = 44) and (b) September (N = 75).

					Zone			
Month	New/Recapt	1	2	3	4	5	6	7
May	New	14	2	1	1	7	2	0
	Recaptured	7	2	0	0	7	1	0
September	New	15	15(11)	1	2	6	1	1
	Recaptured	17	9(6)	0	1	6	1	0

Table 6.2 Number of new and recaptured hedgehogs according to Zone. (Figures in brackets for Zone 2 in September refer to those animals captured in the Zoo car park.)

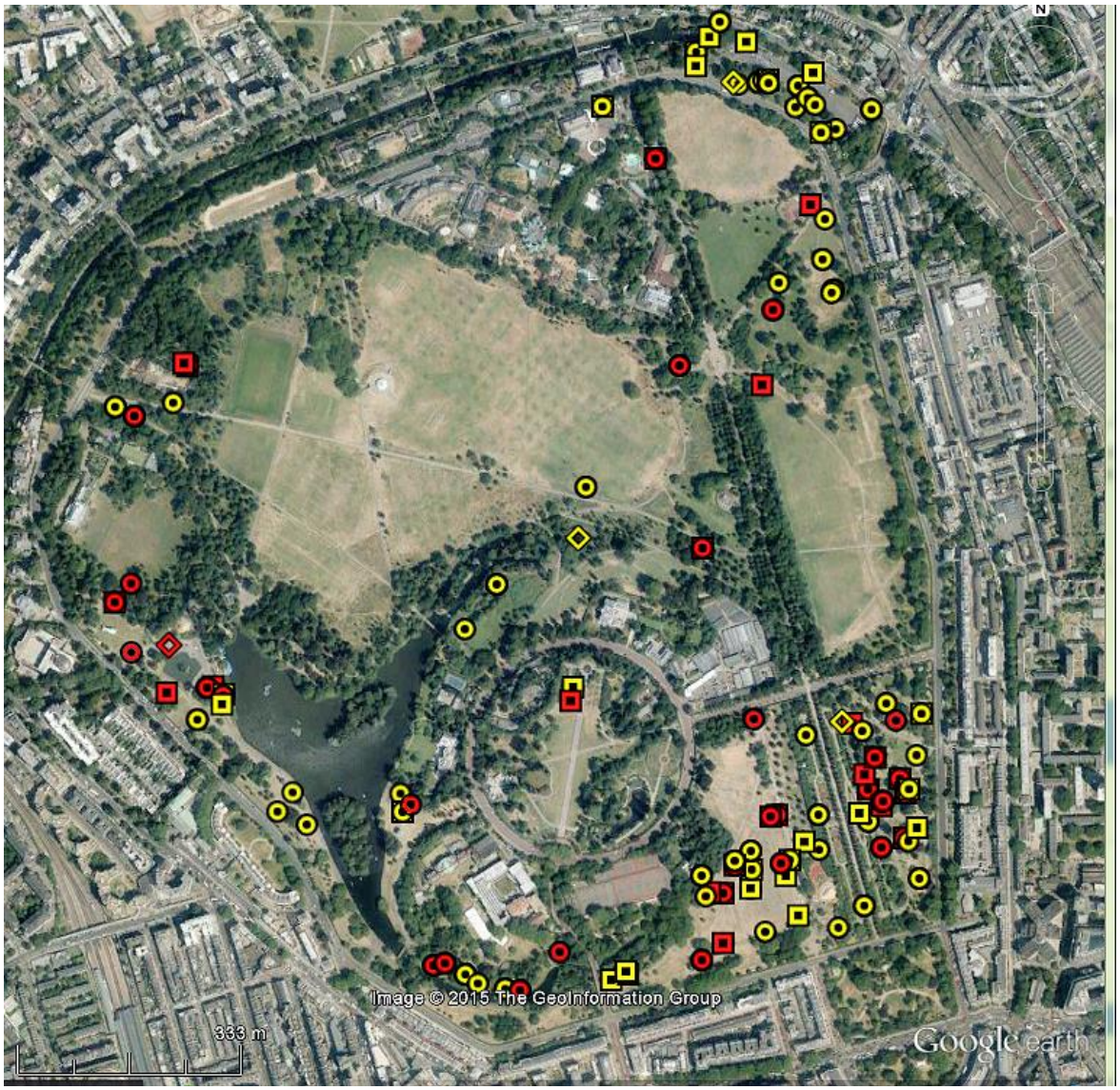


Figure 6.3 Location of hedgehogs captured in Regent's Park. Red = May, Yellow = September, square = male, circle = female, diamond = sex unknown.

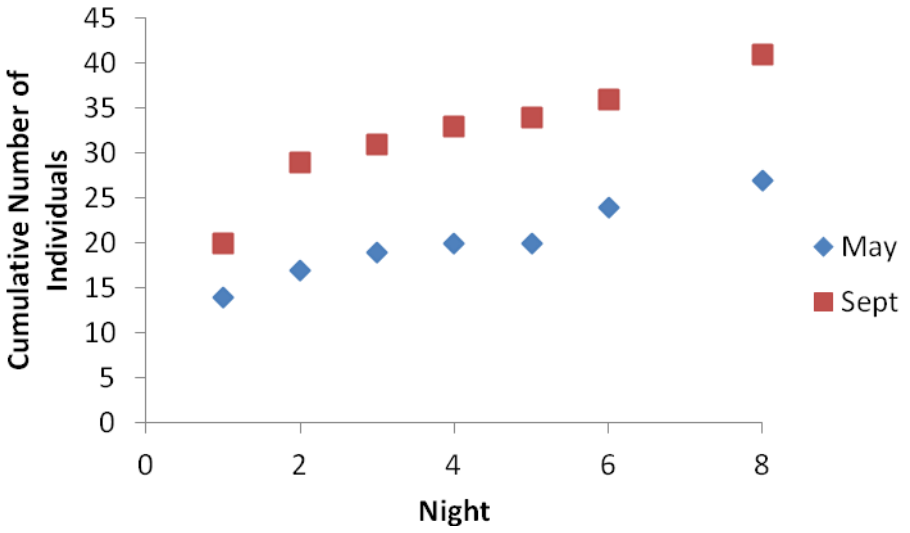
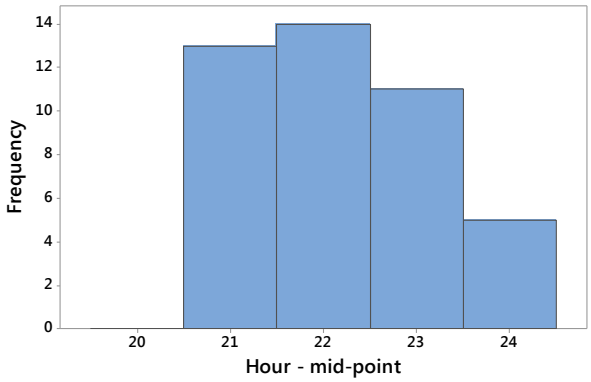


Figure 6.4 The cumulative number of new (unmarked) hedgehogs captured during the survey weeks in May and September. Note, no new hedgehogs were captured in the 7th night in either month. 11% of the hedgehogs were new on the last survey night (Friday - night 8) in May and 12% in September.

(a) May



(b) September

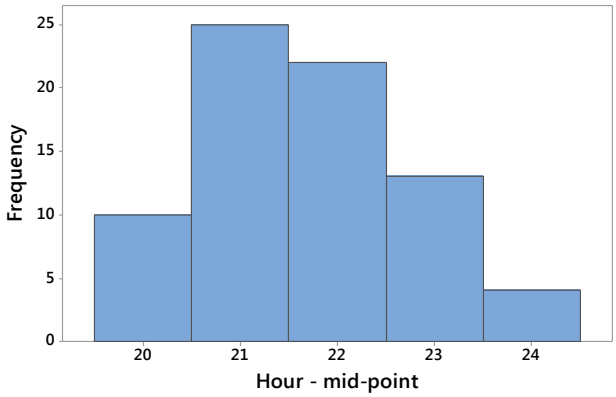


Figure 6.5 Time of capture during spotlighting surveys. Hours represent the hour mid-points, e.g. 21 = 20:30 to 21:30.

6.2. Hedgehog ectoparasites and injuries

Ticks and fleas were common and probably present on most hedgehogs but sometimes went unnoticed and unrecorded. However, ticks were recorded on nine hedgehogs in May; one individual with many ticks, and 13 in September; three with many ticks. Equivalent figures for fleas were five hedgehogs in May, one with many, and 12 in September. None of these animals were considered to require treatment.

No animals were sick, injured or in poor condition in September, but eight animals carried injuries/infections in May, of which five died or were euthanased (Table 6.3). A total of seven animals were found with healed, damaged or missing hind legs or feet.

One sick animal (No. 2) was taken to the vets on the first night (23rd May), treated for an ear infection and successfully released the next evening.

Another hedgehog was captured on the first night with a missing back foot and a seriously damaged leg (No. 999). She was taken to the vets where she was euthanased.

Two were first captured with hind limb injuries but appeared well otherwise and were released (Nos. 59 and 60). One animal (No. 60) appeared to have sustained some damage to a leg during the week, but the wound appeared to be healing when captured on 30th May and the animal was released.

One unmarked animal was found by volunteers in the field during the daytime. It was unable to move and died in transit to the vet. A post mortem showed it suffered from a pulmonary infection, blood in the urine and trauma to the tissues around the neck.

One animal (No. 4) was found dead in The Avenue Gardens with a damaged hind leg on the second Friday (30th May) of the survey; it was first captured a week earlier.

Another hedgehog (No. 54) was found unable to move early in the morning of the 30th after being first captured the week before. It was taken to the vets where it was found to have a bad ear infection and other facial trauma and was euthanased. It also had evidence of old healed damage to the right hind leg.

Both these last two hedgehogs were carrying GPS tags. From the records, it appears that No. 4 sustained its injuries sometime after 21:00 on 27th May. No GPS fixes were obtained on 28th suggested the animal had holed up in deep vegetation, and only three fixes were picked up between 18:44 and 19:47 hours on 29th - she may have died at about this time. In contrast, No. 54 appeared to have restricted activity until shortly before she was found at 6:00 am on the 30th in the children's playground to the north west of the boating lake. She moved into this area between 2:30 and 3:00 hours.

It is unclear why so many leg injuries were found in May. It does not seem connected with the field studies being carried out. One possibility is that the leg injuries were caused by foxes, but this will require further study.

Detailed veterinary reports can be found in Appendix 8.

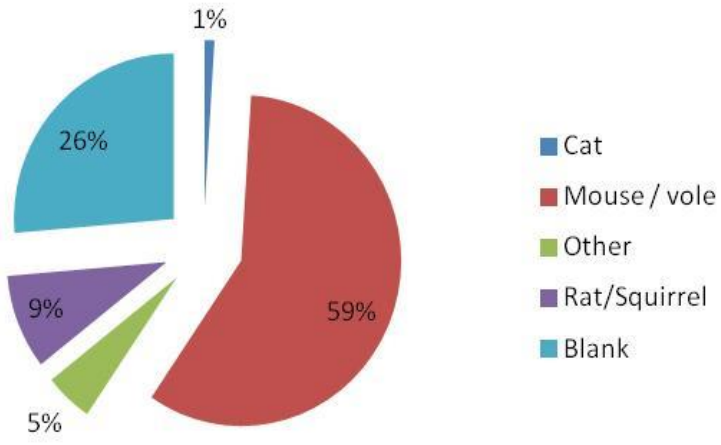
Animal No.	Park Zone	Date	Sex	Weight (g)	Condition	Notes	Outcome
2	1	23/05	F	661	Ear infection, maggots	Treated by vets, maggots removed Old healed fracture of right Tibia	Released. Appeared well on release.
999	2	23/05	F	680	Missing hind right foot, badly damaged leg	Non healing stump	Euthanased by vet
54	5	30/05	M	950	Leaning on left hand side, could not roll up well, not very responsive	First caught 23/5/14 Radiotagged Both ears infected and filled with fly larvae. Old, healed hind right leg fracture	Euthanased by vet
No number	5	29/05	F	Not known	Found unable to move, clearly unwell, covered in fleas	Pulmonary infection. Blood in urine. Bleeding in tissues around the neck	Died in transit to vet
4	1	30/05	M	760	Found dead, hind right leg punctured	First caught on 23/5/14 Radiotagged Hind right leg broken in several places	Found dead
61	1	24/05	M	550	Missing right hind foot	Old open fracture of right hindlimb. Infection	Euthanased by vet
59	1	24/05	F	Not known	Hind right leg missing	Swollen anus. Otherwise appeared well and mobile	Left in field
60	1	30/05	M	700	Damaged hind right leg, appeared to be healing	Also captured on 24/5/14 when damaged leg not reported	Left in field

Table 6.3 Hedgehog injuries in May survey. No injured hedgehogs were found in the September survey. Animals 59 & 60 were not treated by the veterinary team.

6.3 Footprint tunnels

Footprint tunnels were unsuccessful in detecting hedgehog presence in the Park or London Zoo; no hedgehog footprints were detected in tunnels, either in the intensive and widespread survey in May or the more restricted survey in September. Camera traps placed at selected tunnels (see below) detected hedgehogs moving past tunnels on six occasions in May. In May most prints were of mice or voles, with many tunnel inspections drawing a complete blank (Figure 6.6). In September most prints were of mice and voles and slugs.

(a) May (N =238 tunnel inspections)



(b) September (N = 36 tunnel inspections)

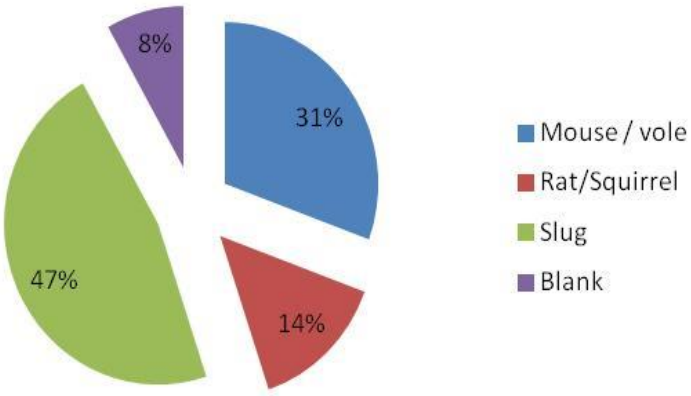


Figure 6.6 Footprints/signs of animal species identified in the footprint tunnels in (a) May and (b) September.

6.4. Camera traps

All camera traps positioned in the Park were directed at hedgehog tunnels. In September four cameras were used in the Zoo grounds over an extended period of 10 days between 19th and 30th September. These were not placed at tunnels or baited but were directed at locations that hedgehogs might have used as pathways.

The number of videos of different species of animals recorded does not reflect the number of individuals. It is likely that the same individuals were recorded a number of times. The video data are further complicated by two cameras being directed at the same tunnel from different angles in many instances. However, the findings can be viewed as the general indicator of animal activity.

6.4.1 May

In May, 158 videos of animals were recorded (Figure 6.7). Most recordings (70%) were of mice, but foxes were seen on 12% of videos and hedgehogs on 6%. Further analysis of the hedgehog videos showed that six individual hedgehogs were recorded on four different nights; the hedgehogs showed no interest in entering the tunnels (Figures 6.9 – 6.16). One tunnel and two cameras were placed in the grounds of Winfield House on 1 June and one hedgehog was seen moving past the tunnel (Figure 6.17).

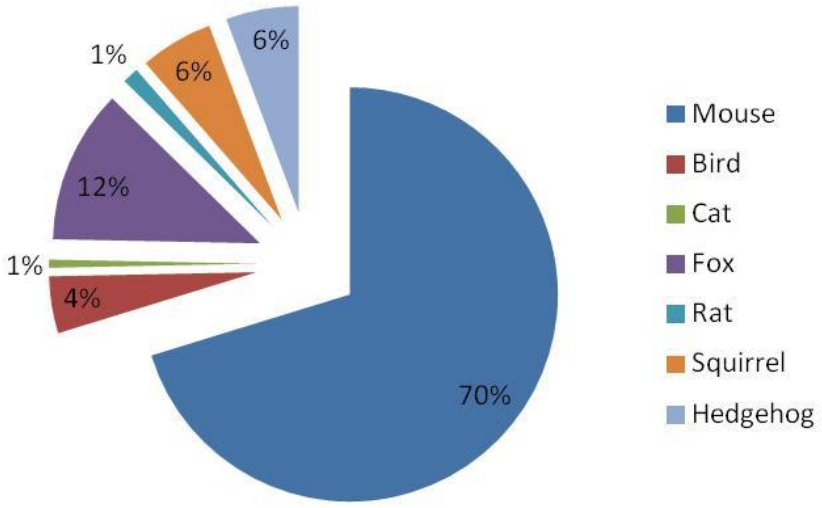
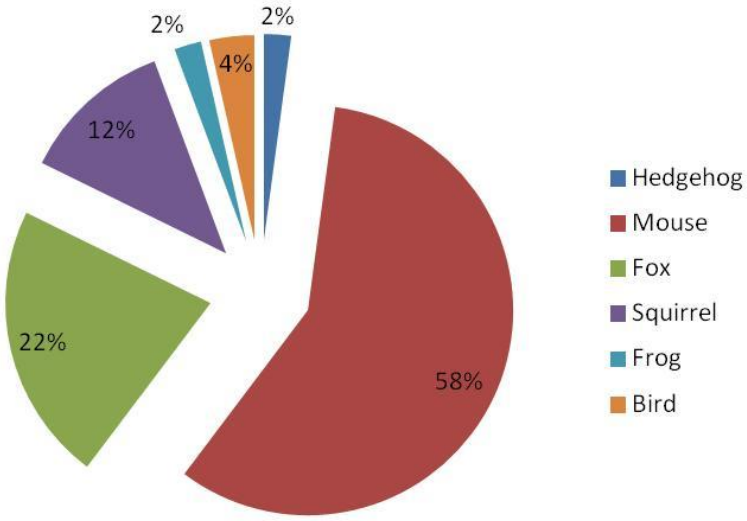


Figure 6.7 Proportion of videos recorded in May showing different species of animals (number of videos = 158).

6.4.2 September

In the Park in September, 141 videos were recorded (Figure 6.8a). Again, most videos were of mice (58%) but there were relatively more fox videos (12%) and fewer hedgehog videos (2%). In fact the hedgehog videos were of the same animal, but again it showed no interest in entering the tunnel (Figures 6.18 – 6.20). The Zoo videos were principally of squirrels, with some recordings of birds, rats and foxes; no hedgehogs were seen (Figure 6.8b). Collectively, the data from May and September show that foxes were active in the same areas as hedgehogs and support the observation that they roamed widely in the Park.

(a) Park



(b) Zoo grounds

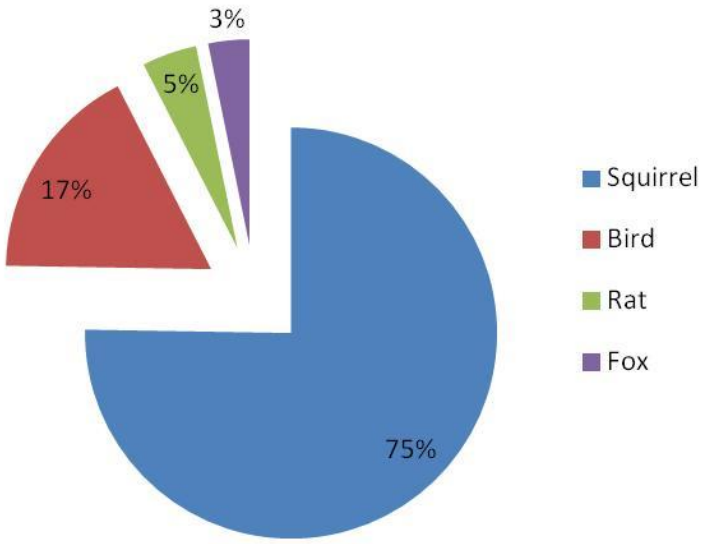


Figure 6.8 Proportion of videos recorded in September showing different species of animals, (a) in the Park (number of videos = 141) and (b) in the Zoo grounds (number of videos = 186).

Figure 6.9 Day 3: 25 May 2014: Camera 1: Hedgehog sighting 1a

Figure 6.10 Day 3: 25 May 2014: Camera 8: Hedgehog sighting 1b

Figure 6.11 Day 3: 25 May 2014: Camera 8: Hedgehog sighting 1c

Figure 6.12 Day 3: 25 May 2014: Camera 1: Hedgehog sighting 2a

Figure 6.13 Day 3: 25 May 2014: Camera 1: Hedgehog sighting 2b

Figure 6.14 Day 5: 27 May 2014: Camera 2: Hedgehog sighting 3

Figure 6.15 Day 5: 27 May 2014: Camera 4: Hedgehog sighting 4

Figure 6.16 Day 7: 29 May 2014: Camera 4: Hedgehog sighting 5

Figure 6.17 Winfield House: 01 June 2014: Hedgehog sighting 6

Figure 6.18 Day 1: 7 Sep 2014: Camera 7: Hedgehog sighting 7a

Figure 6.19 Day 1: 7 Sep 2014: Camera 7: Hedgehog sighting 7b

Figure 6.20 Day 1: 7 Sep 2014: Camera 8: Hedgehog sighting 7c

6.5 Radio tracking

6.5.1 Nest sites

The nest sites of radio-tracked hedgehogs were located during the day and early evening on several days during the survey week. Combining the results from the May and September surveys revealed that just under 50 % of hedgehogs used more than one nest site within the survey week (Figure 6.21). Three quarters of nests were located in informal shrubbery, with the remainder in formal shrubbery or hedgerows. The positions of nests of tracked hedgehogs are shown in Figure 6.22.

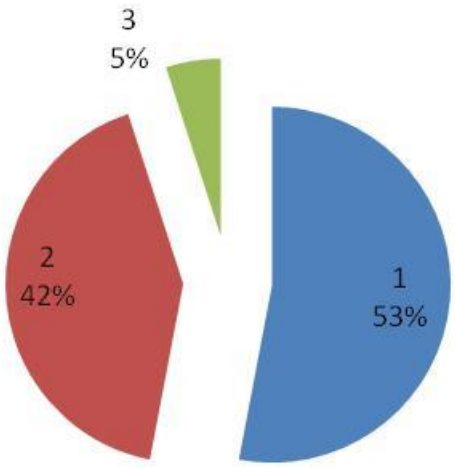


Figure 6.21 Number of nests used by individual hedgehogs during the survey week (May and September combined). N = 19 hedgehogs.

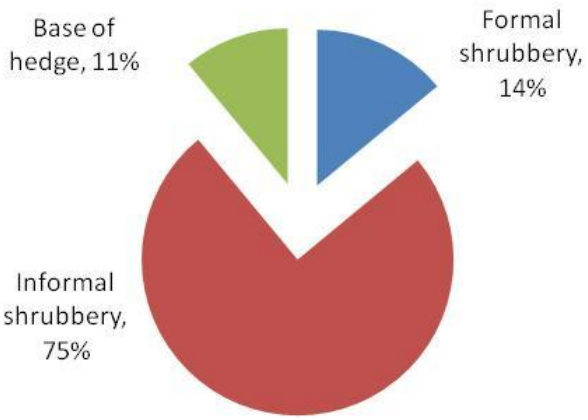


Figure 6.22 Position of nests in May and September combined (N = 29 nests).

6.5.2 Behaviour

In the main, active radiotracked hedgehogs were either foraging or moving (slow or fast locomotion) when found, but some were stationary (Figure 6.23). Most foraging was observed in grassland with some in informal shrubbery and a small amount under hedgerows (Figure 6.24).

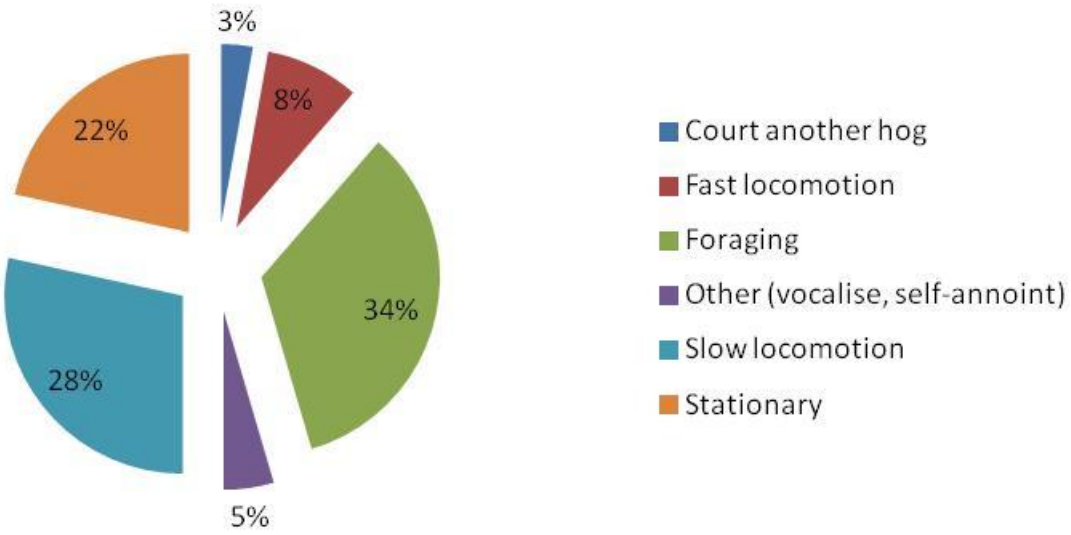


Figure 6.23 Behaviours recorded while Radio tracking hedgehogs, May and September data combined (N = 176 behaviours).

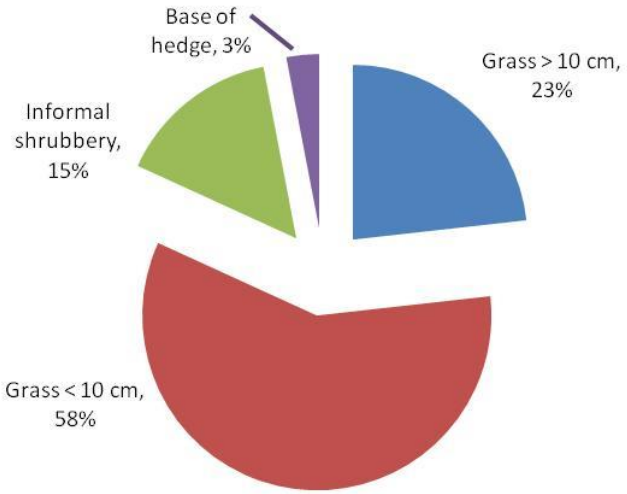


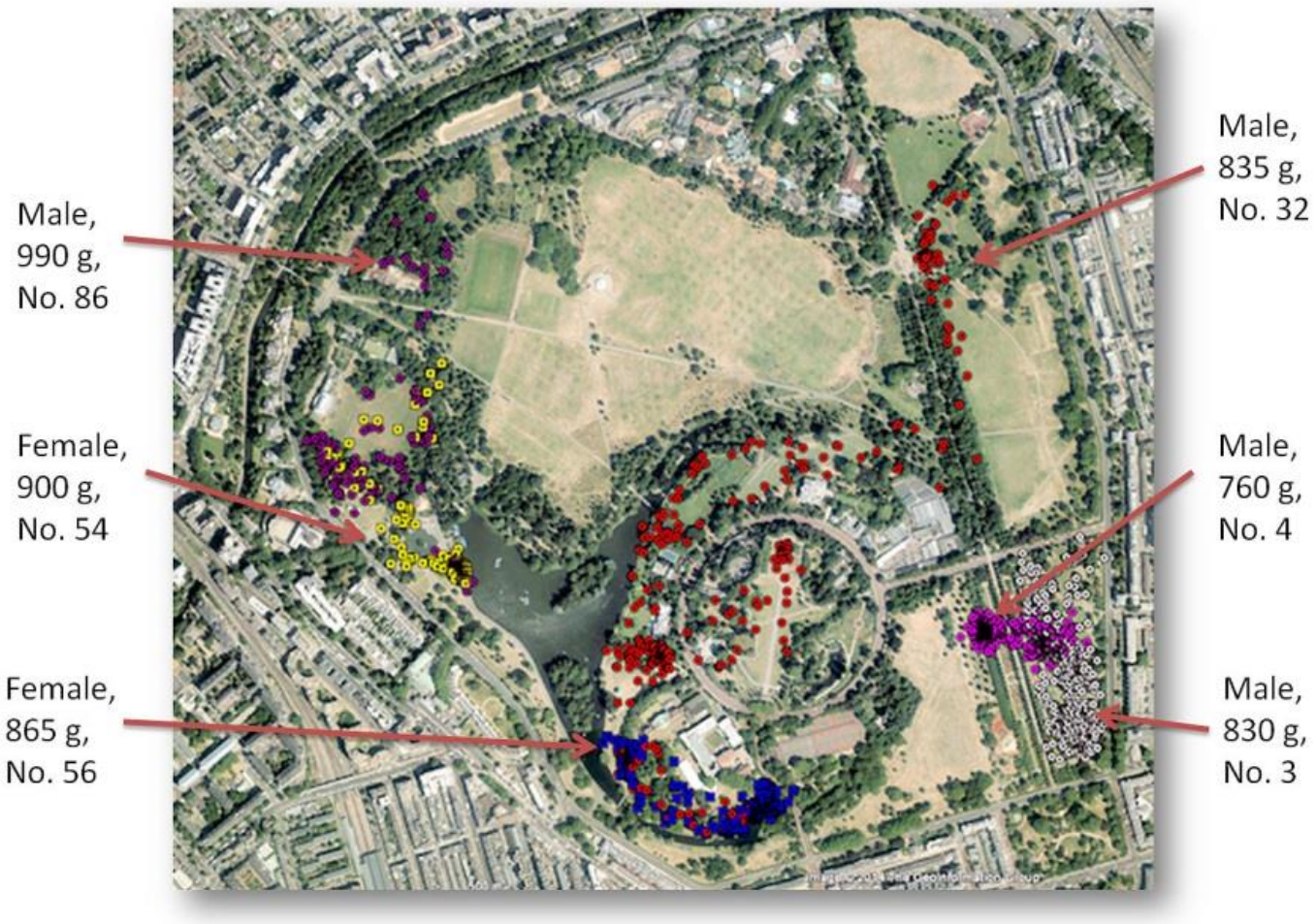
Figure 6.24 Habitat of hedgehogs when foraging, May and September data combined (N = 60 behaviours).

6.6 GPS tracking

6.6.1 GPS fixes

During the May survey 1017 positional GPS fixes were obtained on six hedgehogs (mean per hedgehog = 170, standard deviation (SD) = 55.9) and during September 2475 fixes of 10 hedgehogs (mean per hedgehog = 248, SD (83.2) (Figure 6.25). Occasionally GPS tags stopped picking up satellite signals for periods of time and overall the number of nights that hedgehogs were tracked varied between four and seven, with one hedgehog tracked for 12 nights in September (Appendix 7c). The number of days that hedgehogs were tracked was similar overall (Appendix 7c). In general fixes clustered together in discrete parts of the Park with the exception of one animal in May, Male No. 32, that moved across a large area during the week; probably searching for mates (Figure 6.13).

(a) May



(b) September

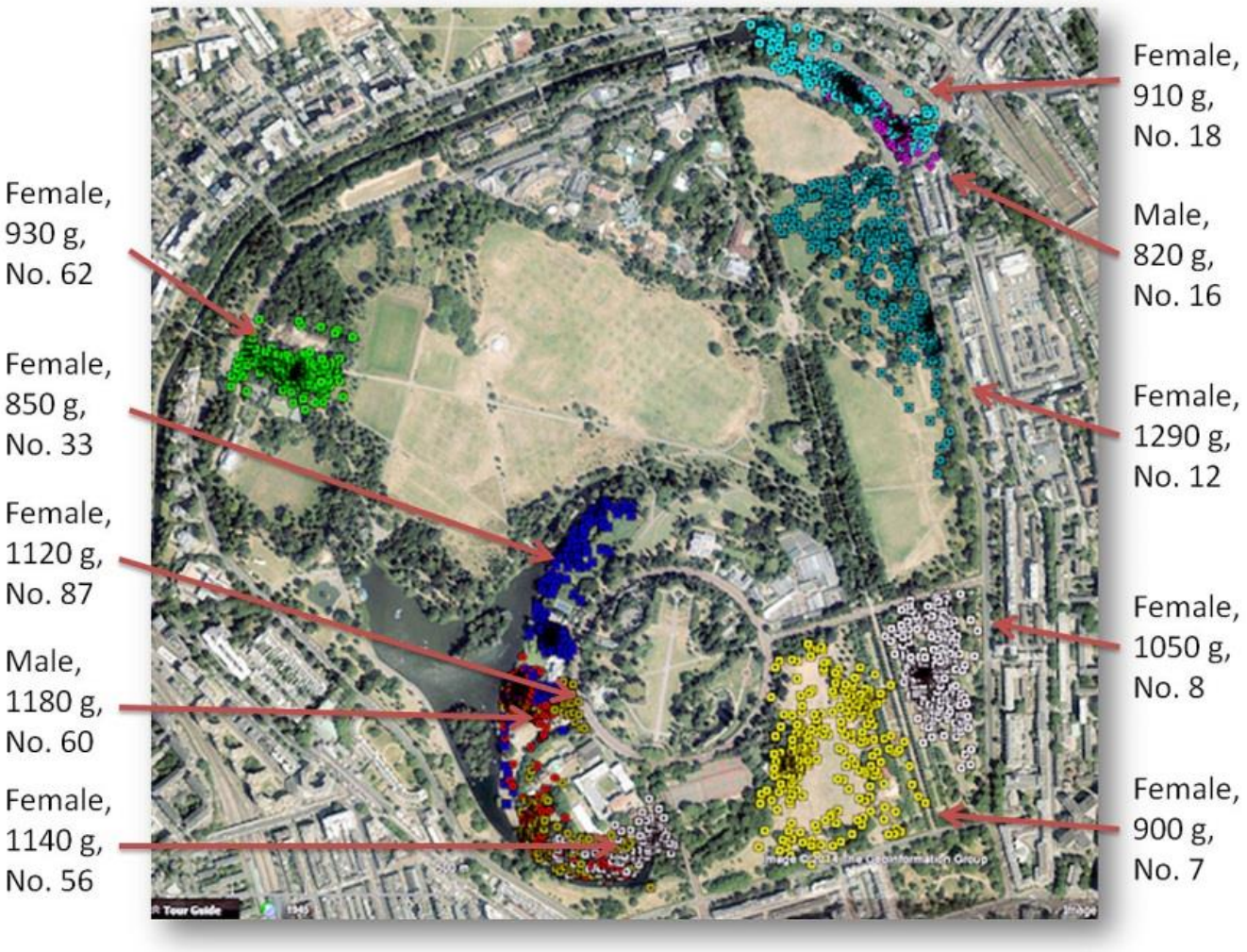
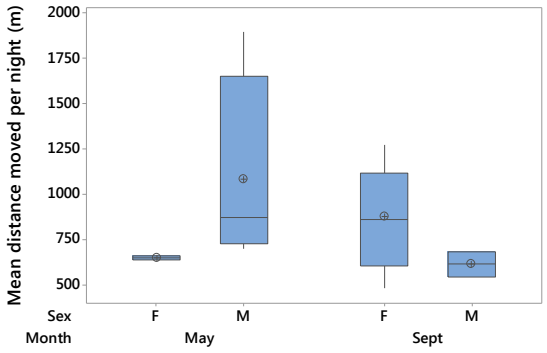


Figure 6.25 GPS fixes of tracked animals in (a) May and (b) September

6.6.2 Night time distance movement and home ranges

The average distance moved by a hedgehog each night varied between 480 m and 1900 m (Figures 6.26, Appendix 7c). Because male No. 32 in May moved over an unusually large area, Figures 6.26, 6.27 and 6.29 displaying variation in movement and home range metrics include and exclude this animal. Excluding No. 32, the overall mean distance moved per night was 798 m (SD = 229.8, N = 15). There were no significant differences between 'Sex' or 'Month' for distance moved (Mann-Whitney tests, all p>0.05). Because of an imbalance in sample size, it was not possible to see if there was a sex-month interaction.

(a) All hedgehogs



(b) All hedgehogs except male 32 in May

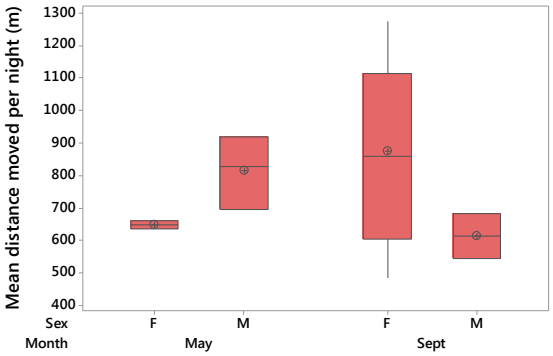
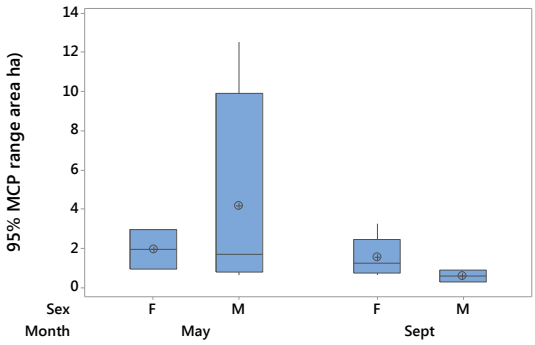


Figure 6.26 Boxplots of distance moved (m) by hedgehogs during the night based on mean values for each individual. The top of each box is the third quartile, the bottom the first quartile; the horizontal line in the middle of each box is the median; the upper and lower whiskers represent the highest and lowest values respectively; the crosses mark the mean values.

95% Minimum Convex Polygons (MCP) for each hedgehog for all nights of tracking are presented in Appendix 7c and Figures 6.27 and 6.28. Excluding No. 32, weekly ranges for each hedgehog varied between 1 ha and 11 ha (Figure 6.28) with mean values for hedgehogs in each month and of each sex varying between 0.5 ha and 2 ha (Figure 6.27). The overall MCP area was 1.44 ha (SD = 0.94, N = 15). There were no significant differences between sex or month for MCP range areas (Mann-Whitney tests, all p>0.05).

(a) All hedgehogs



(b) All hedgehogs except male 32 in May

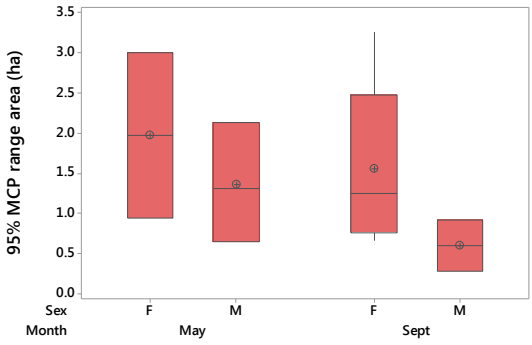
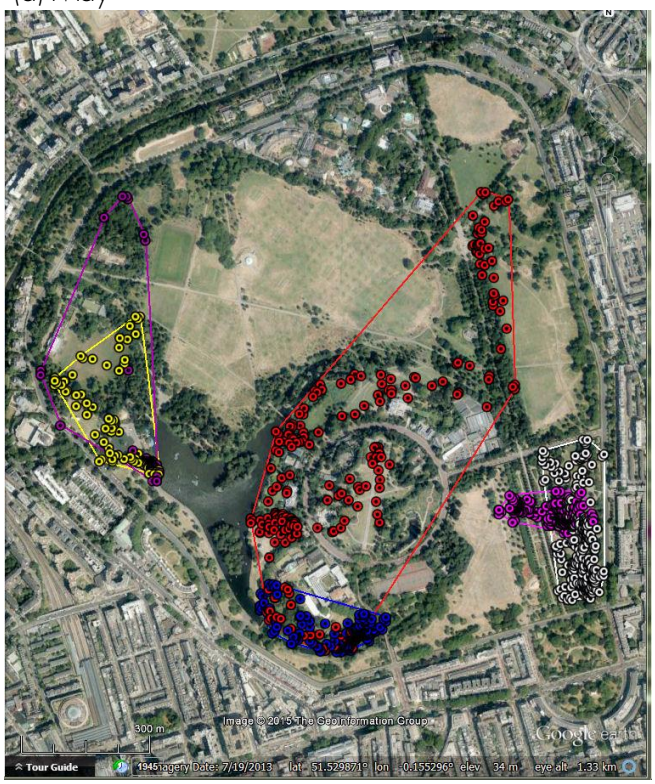


Figure 6.27 Boxplots of hedgehog 95% MCP range areas (ha) during the night based on mean values for each individual.

(a) May



Colour	Animal No.	Sex	MCP (ha)
Red	32	M	35.6
Fuchsia	4	M	1.6
White	3	M	4.5
Blue	56	F	3.0
Yellow	54	F	5.4
Purple	86	M	11.0

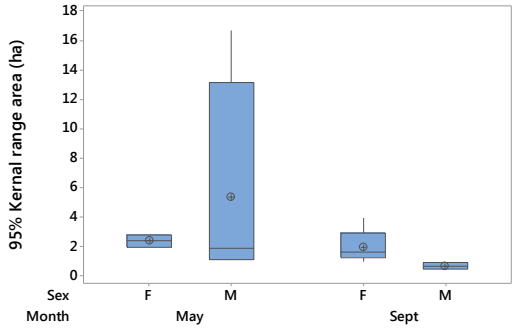
(b) September

Colour	Animal No.	Sex	MCP (ha)
Cyan	18	F	3.3
Fuchsia	16	M	1.4
Teal	12	F	7.7
White	8	F	3.7
Yellow	7	F	8.2
Silver	56	F	2.4
Red	60	M	4.7
Olive	87	F	5.6
Blue	33	F	5.6
Green	62	F	1.9

Figure 6.28 100% MCP (ha) and GPS fixes for each hedgehog (a) May, (b) September

95% kernel home range areas are summarised in Appendix 7c and Figure 6.29; nightly ranges are shown graphically in Figure 6.30. Kernel ranges tended to be larger than MCP ranges (mean per hedgehog = 1.79 ha, SD = 0.88, N = 15), probably because the contouring enclosed larger areas of unused habitat. However, there was a reasonable correlation between the two estimates of home range area (r_s = 0.83, p<0.001, N = 15, Appendix 7d). Interestingly, the mean distance moved per night correlated less well with either of the measures of home range area (Appendix 7d) suggesting that movement within a range does not predict home range size. There were no significant differences between sex or month for MCP range areas (Mann-Whitney tests, all p>0.05). Although most hedgehogs tended to remain in the same general area, it is clear that many moved over different parts of their home range on different nights and that many had more than one core area they used each night. This probably reflects bouts of foraging.

(a) All hedgehogs



(b) All hedgehogs except male 32 in May

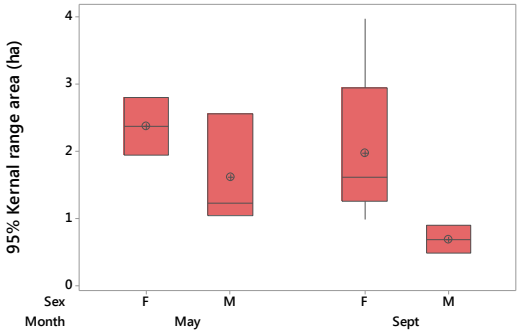
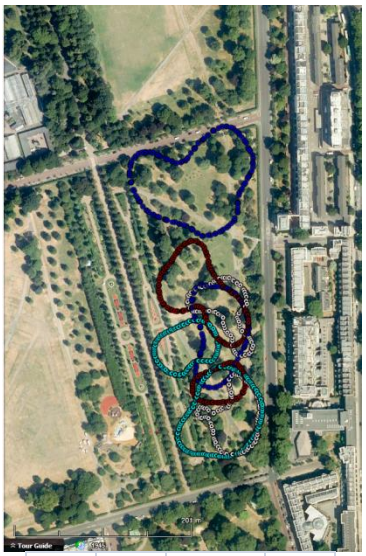
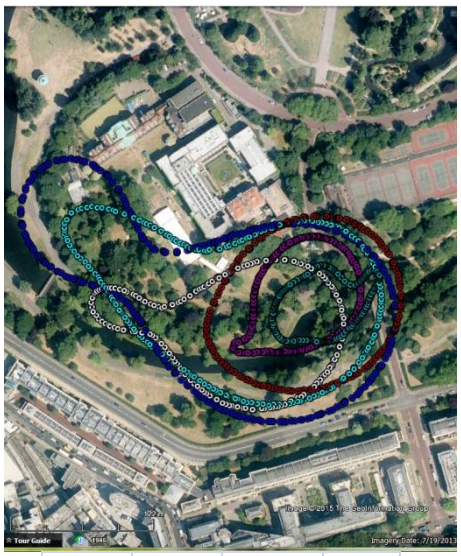


Figure 6.29 Boxplots of hedgehog 95% kernel range areas (ha) during the night based on mean values for each individual.

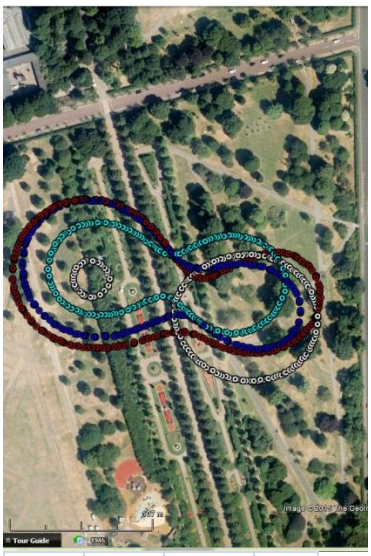
(a) May



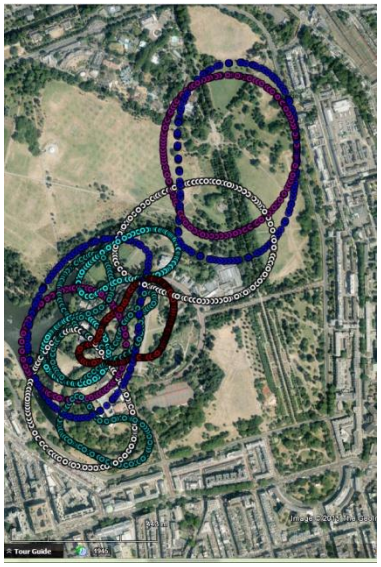
Animal No.	Sex	Colour	Area (ha)
3	M	White	0.66
		Blue	1.66
		Cyan	1.03
		Maroon	0.83



Animal No.	Sex	Colour	Area (ha)
56	F	White	1.70
		Blue	3.88
		Cyan	3.02
		Maroon	1.92
		Teal	0.41
		Purple	0.75



Animal No.	Sex	Colour	Area (ha)
4	M	White	0.85
		Blue	1.39
		Cyan	0.98
		Maroon	1.73



Animal No.	Sex	Colour	Area (ha)
32	M	White	23.487
		Blue	33.091
		Cyan	6.7148
		Maroon	4.3468
		Teal	8.7436
		Purple	23.972

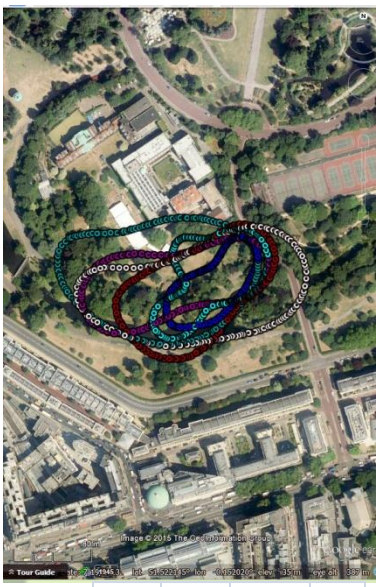
Animal No.	Sex	Colour	Area (ha)
86	M	Cyan	1.07676
		Maroon	2.97672
		Teal	2.99368
		Purple	2.01605
		Green	3.7325

Animal No.	Sex	Colour	Area (ha)
54	F	Cyan	1.10
		Maroon	4.53

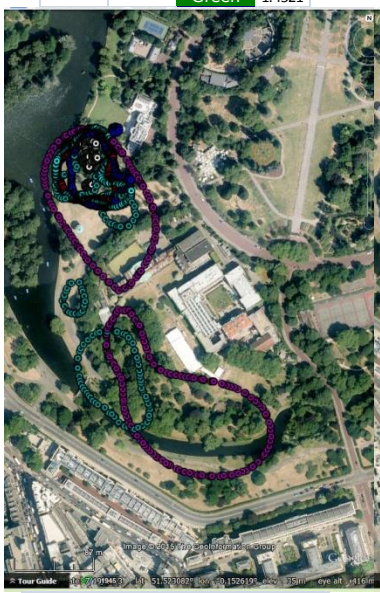
(b) September

Animal No.	Sex	Colour	Area (ha)
8	F	White	1.3699
		Blue	2.0706
		Cyan	1.9865
		Maroon	1.3435
		Teal	2.3753
		Purple	1.0654
		Green	1.4521

Animal No.	Sex	Colour	Area (ha)
7	F	White	3.36
		Blue	4.16
		Cyan	3.47
		Maroon	4.89
		Teal	3.95
		Purple	4.21
		Green	3.85

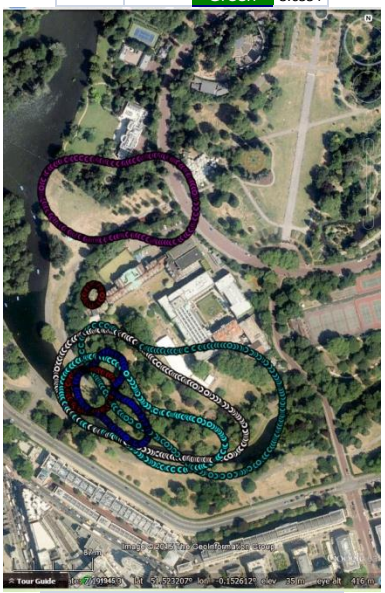


Animal No.	Sex	Colour	Area (ha)
12	F	White	3.431
		Blue	2.7508
		Cyan	3.6984
		Maroon	3.4487
		Teal	3.0616
		Purple	4.1203
		Green	3.0554

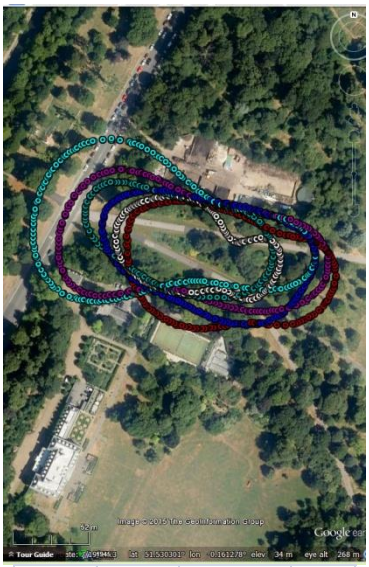


Animal No.	Sex	Colour	Area (ha)
60	M	White	0.0308
		Blue	0.3592
		Cyan	0.4366
		Maroon	0.3875
		Teal	1.0496
		Purple	3.1913

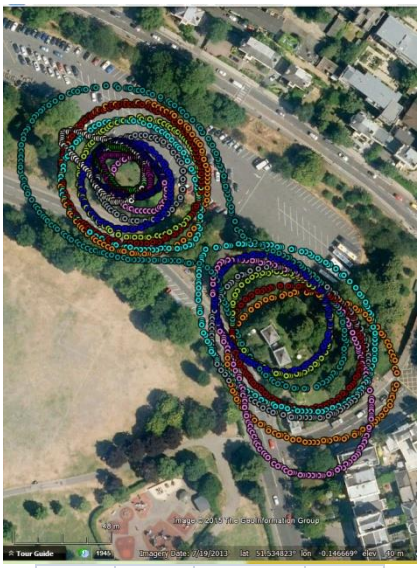
Animal No.	Sex	Colour	Area (ha)
56	F	White	1.99
		Blue	0.50
		Cyan	0.79
		Maroon	1.36
		Teal	2.05
		Purple	1.23



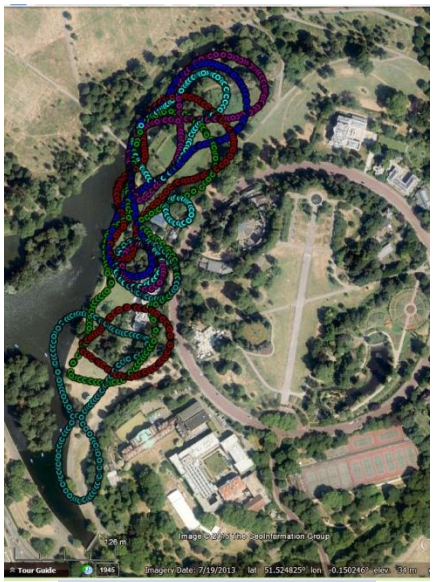
Animal No.	Sex	Colour	Area (ha)
87	F	White	1.88
		Blue	0.41
		Cyan	1.14
		Maroon	0.24
		Teal	2.35
		Purple	1.38



Animal No.	Sex	Colour	Area (ha)
62	F	White	0.55
		Blue	0.97
		Cyan	1.44
		Maroon	0.98
		Teal	0.72
		Purple	1.26



Animal No.	Sex	Colour	Area (ha)
16	M	White	0.08
		Blue	0.40
		Cyan	0.90
		Maroon	0.67
		Teal	1.02
		Purple	0.04
		Green	0.04
		Navy	0.06
		YellowGreen	0.47
		SlateGray	0.57
		Orchid	0.63
		DarkOrange	0.90



Animal No.	Sex	Colour	Area (ha)
33	F	Blue	1.62
		Cyan	1.08
		Maroon	1.99
		Teal	1.65
		Purple	1.37
		Green	2.52

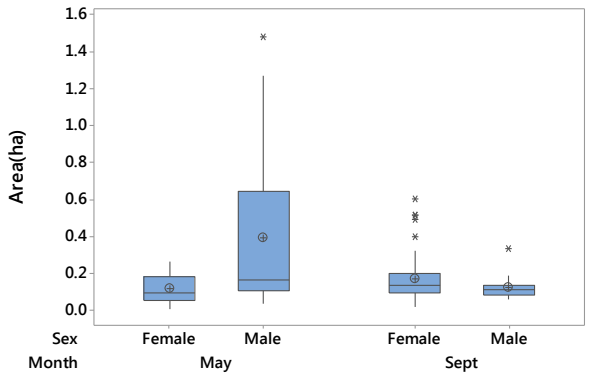
Animal No.	Sex	Colour	Area (ha)
18	F	White	0.49
		Blue	1.39
		Cyan	2.99
		Maroon	1.27
		Teal	3.10
		Purple	1.47
		Green	0.22

Figure 6.30 95% kernel home range areas for each night of tracking (individually coloured) for each hedgehog.

6.6.3 Day time activity and nest sites

Daytime movement and home range metrics are considerably smaller than night time metrics (Figure 6.31, Appendix 7c). However, and although hedgehogs were active on some occasions during the day, especially in the early hours, it is particularly difficult to disentangle movement and GPS positional fix error (see Methods), especially since nest sites were usually deep inside vegetation. For this reason, inferences on distances moved and range areas are not considered here. However, assuming that the centres of daytime range fixes approximate the position of nest sites, they have been plotted together with known positions of nest sites from Radio tracking and MCP weekly range outlines for each animal in Figure 6.32. A visual inspection of these plots show that many day time range centres cluster together, probably representing one nest site, but, as with the findings from Radio tracking, there often appears to be more than one nest site in each range. The positions of some radiotracked nest sites are close to daytime range centres, suggesting they may be one and the same, but not in all cases.

(a) 95% MCP range areas (m^2)



(b) 95% kernel ranges

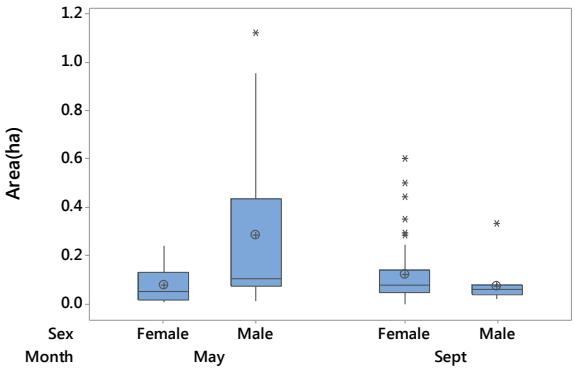
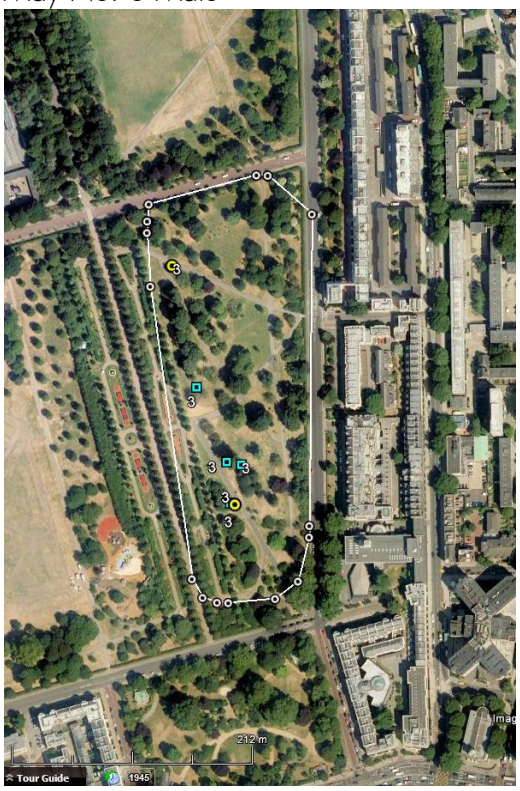
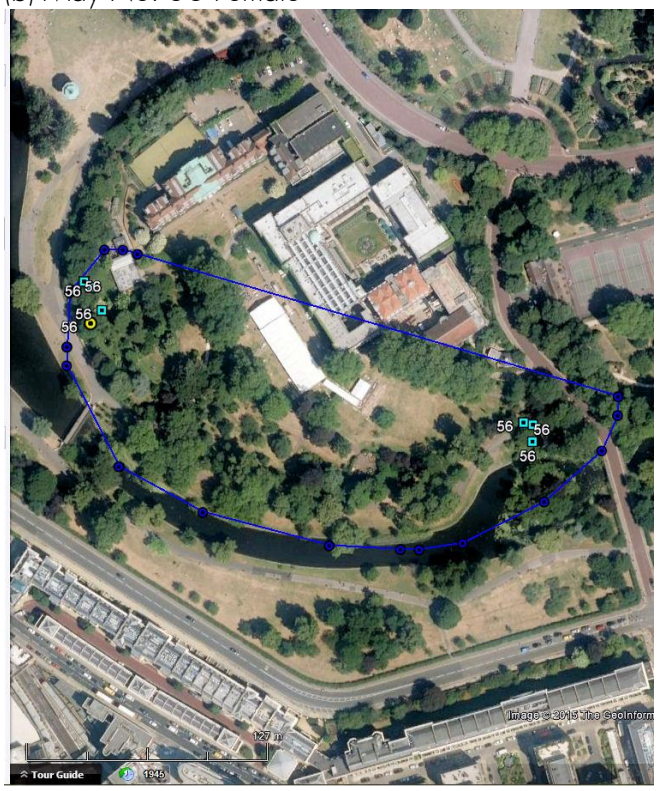


Figure 6.31 Boxplots of hedgehog (a) 95% MCP range areas (ha) and (b) 95% kernel ranges during the day based on mean values for each individual. For the key to symbols, see Figure 6.26; the stars represent outliers (unusually large values).

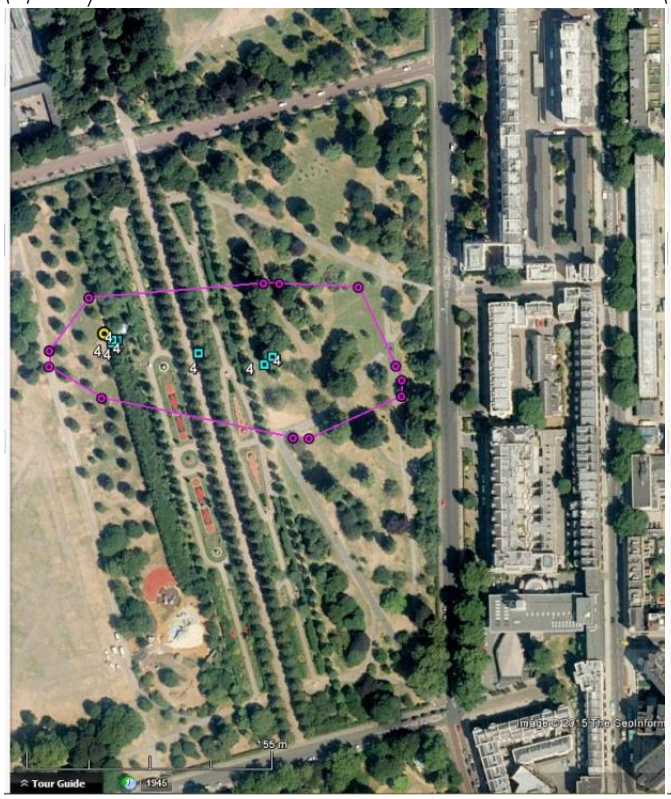
(a) May No. 3 Male



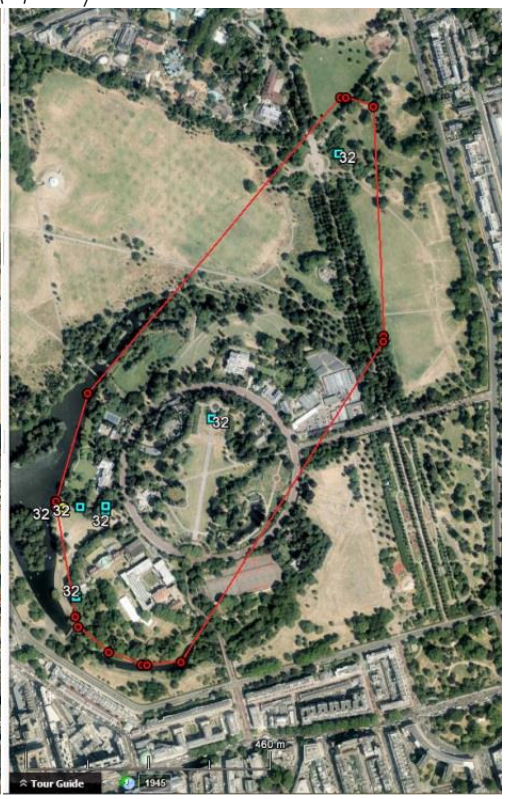
(b) May No. 56 Female



(c) May No. 4 Male

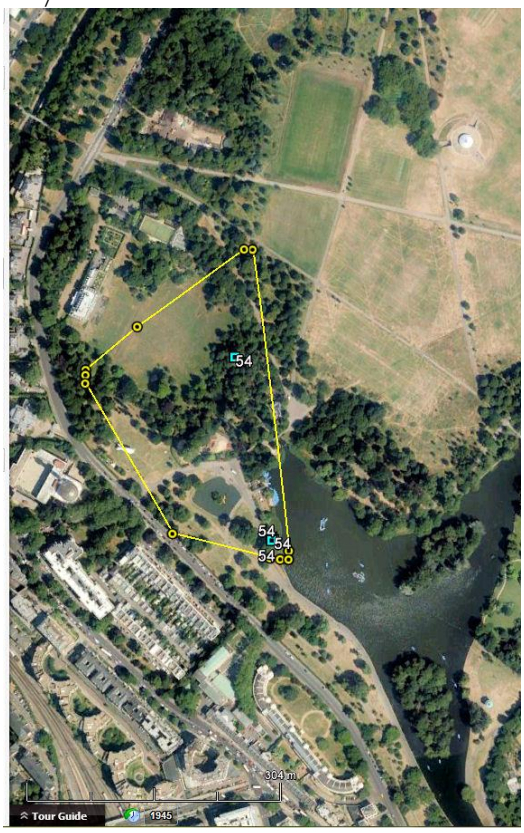


(d) May No. 32 Male



(e) May No. 86 Male

(f) May No. 54 Female

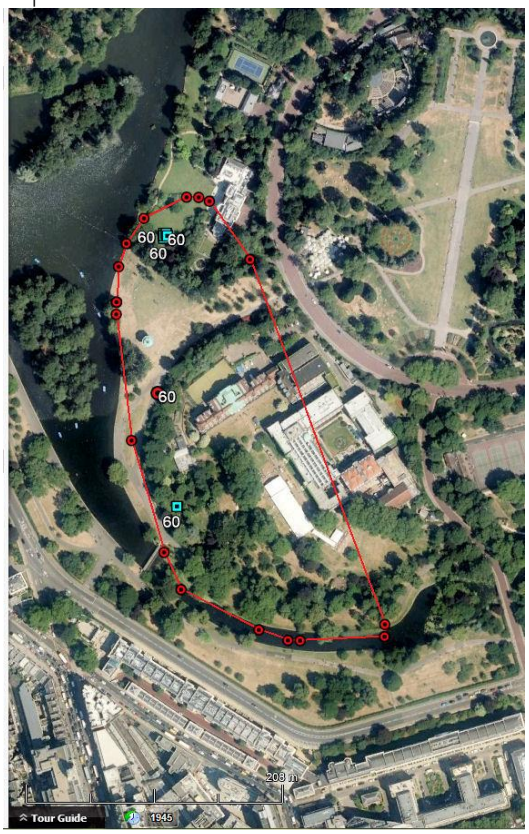


(g) September No. 8 Female

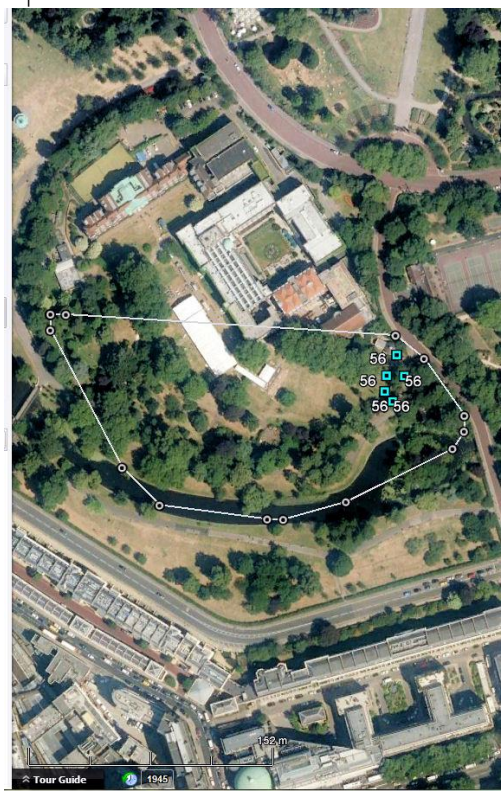
(h) September No. 7 Female

(i) September No. 12 Female

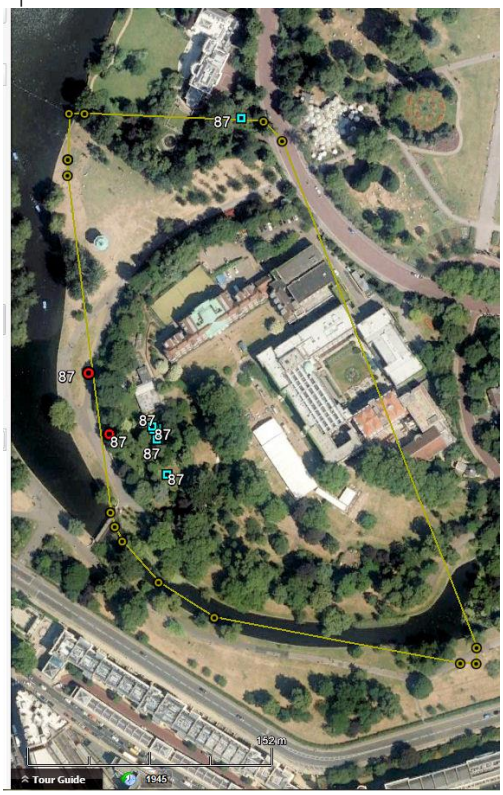
(j) September No. 60 Male



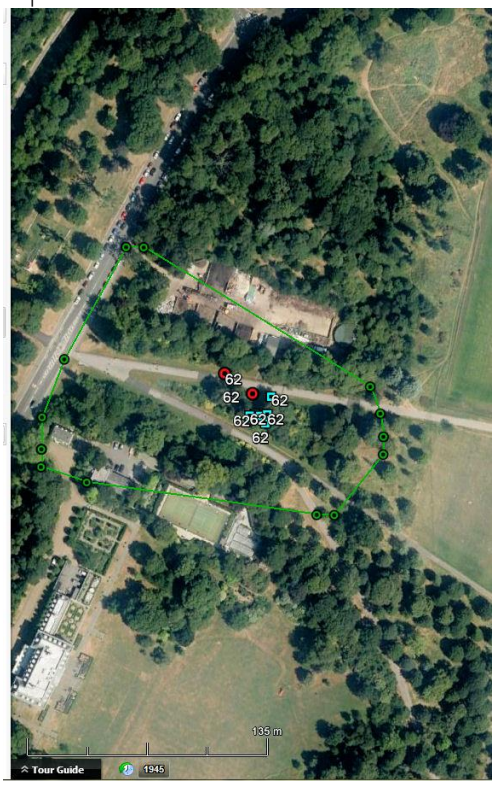
(k) September No. 56 Female



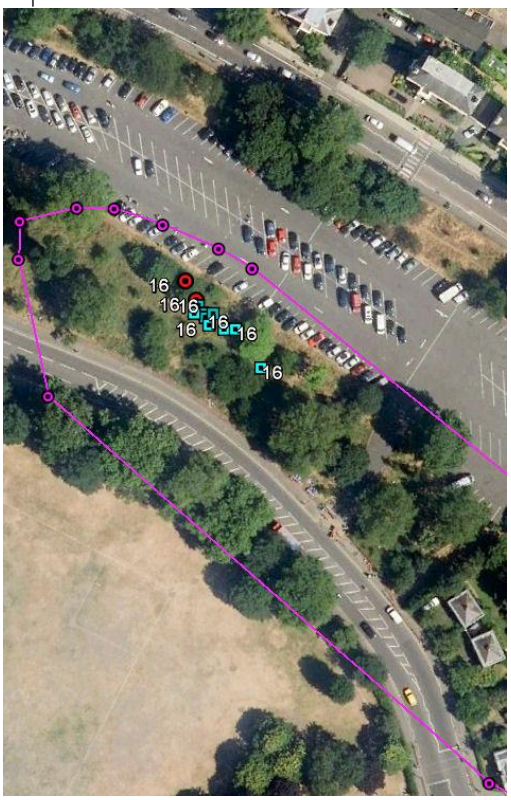
(l) September No. 87 Female



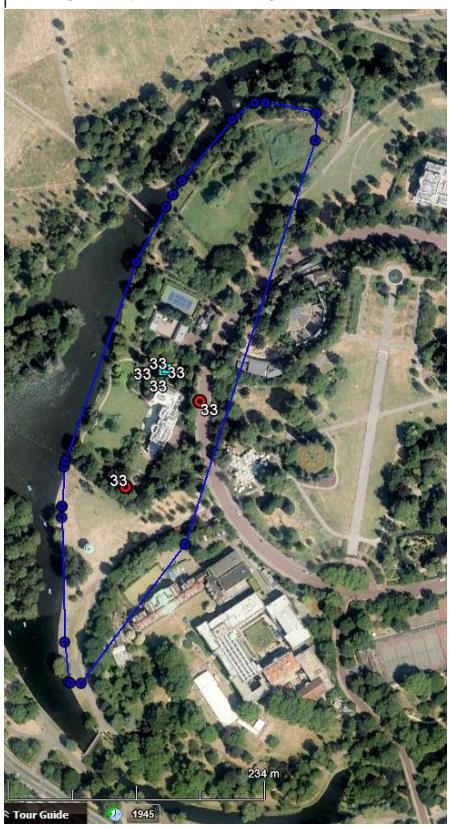
(m) September No. 62 Female



(n) September No. 16 Male



(o) September No. 33 Female



(p) September No. 18 Female

Figure 6.32 Centre of day ranges (cyan) and radiotracked nest sites (yellow - May, red - September overlaid on 95% MCP range areas for each GPS-tracked hedgehog. Note, nest sites were not found for all radiotracked hedgehogs.

6.6.4 Habitat utilisation

Despite GPS positional fix errors, to get some indication of habitat use the large number of fixes have been overlaid onto a habitat map of The Regent's Park, and the habitat at each fix point with a 5 m radius determined (Figure 6.33, Appendix 7e). Habitat use varied among individuals according to the habitat mix within their home ranges (Appendix 7e). Even so, it seems clear that amenity grassland was the most heavily used habitat type from Figure 6.33. In contrast, acid grassland and woodland appear the least used. However, pooling data masks the fact that some animals, for example, used reedbeds and woodland (Appendix 7e). To take account of the different proportions of each habitat type within the 95% MCP range areas of each hedgehog, Jacob's habitat selection indices for point fixes for each individual are presented in Table 6.4. These values range from -1.0, avoidance, to +1.0, strong preference. It can be seen that each individual used the mix of different habitats within its range in a different way. For example, hedgehog No. 4 in May preferred hedgerows and amenity grassland whilst tending to avoid other habitats, whereas hedgehog No.18 in September avoided amenity grassland and preferred improved grassland and roughland.

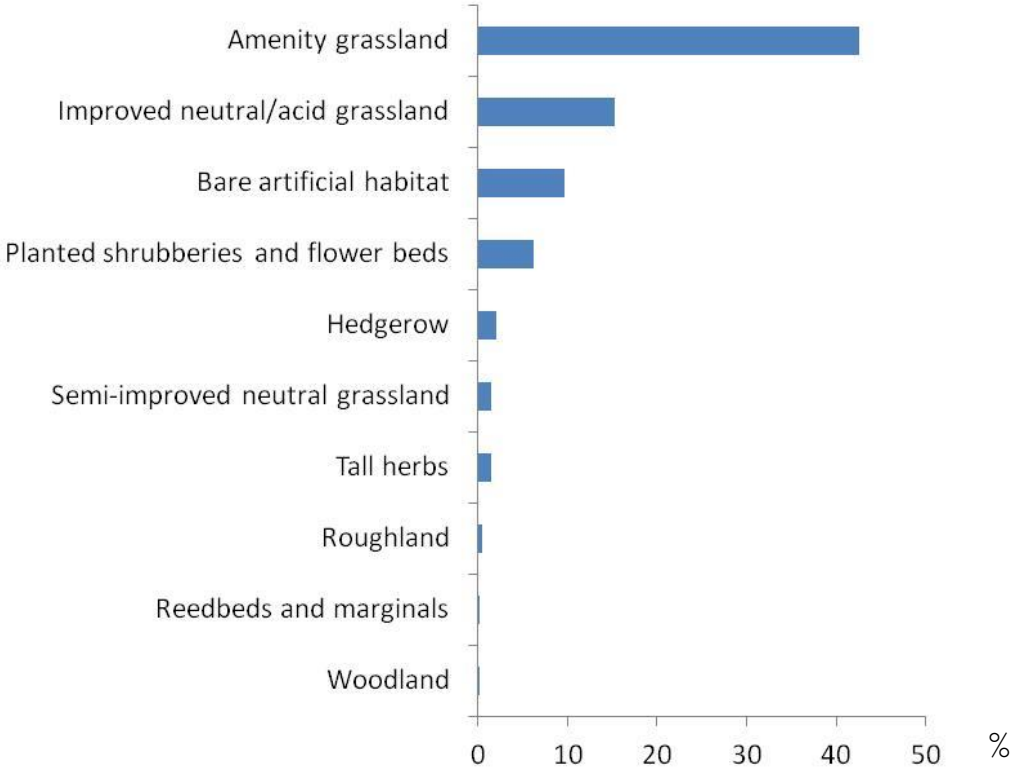


Figure 6.33 Mean percentage of habitat locations, each with a 5 m circle radius, that fall within different habitat types for GPS-tracked hedgehogs - both surveys combine (N=16). Habitats within the Park that were not surveyed are not included.

			Habitat									
Animal No.	Sex	Month	Planted shrubberies and flower beds	Tall herbs	Improved neutral/acid grassland	Roughland	Semi-improved neutral grassland	Woodland	Hedgerow	Reedbeds and marginals	Bare artificial habitat	Amenity grassland
3	M	May	-0.16		-0.47				-0.44		0.03	0.13
56	F	May	0.17	0.86	-0.26		-0.52				0.40	0.35
4	M	May	-0.15		-0.18				0.30		-0.43	0.14
32	M	May	-0.46	0.40	-0.16	-0.94	0.29		-0.27	-0.94	-0.49	0.44
86	M	May	-0.52	-0.71	0.45	0.36		0.51	0.38	0.35	-0.86	0.16
54	F	May			0.04				0.28	0.60	-0.04	0.31
8	F	Sep	0.03		-0.08				-0.36		-0.12	0.08
7	F	Sep	-0.30		-0.94				0.09		-0.13	0.12
12	F	Sep							0.34		0.00	-0.30
60	M	Sep			0.01		-0.17				-0.10	0.24
56	F	Sep	0.06	0.36	-0.50		0.89				-0.03	0.31
87	F	Sep		-0.56	0.09		0.60				0.44	0.22
62	F	Sep	-0.15								0.15	0.26
16	M	Sep			0.44						-0.62	-0.98
33	F	Sep		0.15	0.23		-0.55			0.21	-0.69	0.46
18	F	Sep			0.38	0.28					-0.37	-0.81
Mean			-0.16	0.08	-0.07	-0.10	0.09	0.51	0.04	0.05	-0.18	0.07

Table 6.4 Jacob's habitat selection indices for each GPS-tracked hedgehog (values -1 to +1)

It can be seen that obtaining a complete picture for habitat use across the Park as a whole for all hedgehogs tracked is difficult, but here the differences between the sum of negative Jacob's Indices <-0.1, and positive indices (>+0.1) have been ranked in Table 6.5 (indices close to zero indicate no selection). Amenity grassland again comes out as best, but now reedbeds and woodland fare better. Although the results from this analysis must be treated with caution, it is interesting to note from this preliminary analysis that improved neutral/acid grassland and planted shrubberies/flowerbeds appear to have been avoided.

Pos	Neg	Diff	Habitat
12	3	9	Amenity grassland
4	2	2	Tall herbs
3	1	2	Reedbeds and marginals
2	1	1	Roughland
1	0	1	Woodland
4	3	1	Hedgerow
3	3	0	Semi-improved neutral grassland
4	6	-2	Improved neutral/acid grassland
1	6	-5	Planted shrubberies and flower beds
3	9	-6	Bare artificial habitat

Table 6.5 Ranking of habitat types according to Jacob's indices. Pos = Jacobs Indices >+0.1, Neg - Jacob's Indices <-0.1, Diff = Pos-Neg.

7. Discussion

7.1 Study methods

Hedgehog footprint tunnels were first used as a survey tool by Huisjer & Berger (2000). They were adapted and advocated as a national survey and monitoring tool (see Anon 2014, Yarnell *et al.* 2014) but proved ineffective at The Regent's Park in 2014. Footprint tunnels were placed at 65 locations during May and inspected a total of 238 times but no hedgehog footprints were found. The tunnel survey was scaled down in September and tunnels were placed at eight locations and inspected 36 times; again no hedgehog footprints were identified. Prints or signs of several other animals were found including: cat, mouse/vole, squirrel/rat and slug. It is impossible to be sure why the footprint tunnels did not work. The standard advice is to place them along linear features such as hedgerows or fence lines since hedgehogs tend to move along these (Hof *et al.*, 2012, Yarnell *et al.*, 2014). Because much of the Park was accessible to the public, it was not always possible to place tunnels along boundaries, but 39% of tunnels were placed at the base of a hedge or within 2 m of linear features in May and 51% in September. Moreover, radio tracking and GPS tracking demonstrated that hedgehogs frequently moved into open areas in the Park, and hedgehogs were filmed moving past tunnels on several occasions. Thus, placement position may not be the reason why hedgehogs were not detected by this method. Haigh *et al.* (2013) also found the use of tunnels disappointing in detecting hedgehogs in rural habitats in Ireland and at one site hedgehogs were frequently observed near tunnels but rarely entered them. They also observed that a hedgehog in a garden study did not enter a tunnel if other food was put out for it, and this was also found to be the case in a study in Surrey (Gurnell unpubl.). Therefore, their lack of success may be because the hedgehogs were not attracted into tunnels when they encountered them.

Camera traps have become a popular survey method for animals in general (Meek *et al.*, 2013, Swan *et al.* 2014), but little work has been done on using them to survey systematically for small mammals such as hedgehogs (De Bondi *et al.*, 2010, Glen *et al.*, 2013). We used ten cameras in conjunction with footprint tunnels to assess whether they would be useful as a survey tool. They detected a range of wildlife at or around the tunnels, including the few occasions that hedgehogs went near the tunnels. In so doing, they generated a lot of pictures/videos which all required careful inspection. Further studies are needed on the use of camera traps, especially with respect to where to put them, whether they should be targeted at focal feed areas (e.g. bait/tunnels) and how they might provide additional information on activity and behaviour.

Haigh *et al.* (2012) assessed trapping, using footprint tunnels and spotlighting for detecting hedgehogs in rural Ireland, and concluded that spotlighting was the most effective method, although they recommended using a combination of methods to test whether hedgehogs were present in particular areas. We also found spotlighting effective and the stratified sampling design using teams of volunteers enabled the whole Park to be surveyed at the same time. Most hedgehogs were detected by sight and in open grassland habitats (aided by the background glow of city lights) rather than by sound in the undergrowth. In some parts of the Park, traffic noise and bird calls from around the boating lake made listening for the sounds of hedgehogs moving in the undergrowth difficult.

Volunteers were not always adept at unrolling hedgehogs to sex them, and more practice would be needed for future surveys. The identification marking system using coloured plastic sleeves in one or two patches on the back of the hedgehogs was reasonably satisfactory; they stayed intact

for the week of the survey, but many of the sleeves attached in May had become dislodged by September making the identification of individuals difficult in five or six cases.

VHF radio transmitters have been used in several studies of hedgehog movement (e.g. Reeve 1982, Morris 1988, Hof & Bright 2010, Hof *et al.* 2012, Rautio *et al.*, 2013), but this is not the case with GPS tags (Glasby & Yarnell, 2013). The use of VHF and GPS tags was successful. No hedgehogs appeared compromised by carrying the tags. In the main, the method of gluing the tags to the backs of the animals worked well. Only two GPS tags came off, in the May survey, otherwise all tags were retrieved at the end of the survey weeks.

Radio tracking using the VHF tags was used to locate the animals carrying GPS tags so they could be retrieved and the stored information downloaded. However, Radio tracking was also used to search for nest sites and, on a limited basis, to find and record the behaviour of the tagged animals and the habitats they were using. The GPS tags were set to log their location every 10 minutes (although gaps occurred in the record when the tags lost satellite signals), and one might expect this to make data from conventional VHF radio tracking redundant. But static tests (see Methods and Appendix 6) had revealed the location accuracy of GPS tags to be at best a 10 m radius in open grassland habitat and considerably worse where an animal was in dense vegetation, by buildings or adjacent to iron railing fences. Nevertheless, GPS tagging is a highly cost-effective way to provide useful data about hedgehog movements (Glasby & Yarnell, 2013) and it is worth noting that with conventional VHF radio tracking, the handheld GPS units used to verify locations may not be much more accurate than the GPS tags. Furthermore during VHF radio tracking, where the animal's location cannot be confirmed by sight, locations recorded by triangulation are likely to be even less accurate than those obtained by GPS tags.

7.2 Numbers and distribution of hedgehogs

This study attempted to find out how many hedgehogs live in The Regent's Park. Eleven individuals were captured in the Zoo car park in September which represents just over a quarter of the September catch. Therefore it was clearly an important area for hedgehogs. The Zoo car park was not searched in May and so it can be assumed that there were maybe six or seven hedgehogs more than the 27 captured in the Park at that time. There were also parts of the Park which were off-limits (e.g. Winfield House, Regent's University London, The Holme); hedgehogs were tracked or seen moving in and out of these areas and they may have harboured some animals which were not captured. Standardised spotlighting searches for hedgehogs across the Park were only carried out at the beginning and end of the survey weeks. However, to build up a detailed picture of the individuals within the Park, unmarked hedgehogs opportunistically found during the week when carrying out Radio tracking were also marked and released. Unfortunately, this uneven search effort precludes estimating population size using conventional methods (e.g. the application of capture-mark recapture methods). Nevertheless, with only just over 10% of the hedgehogs captured being unmarked at the end of the survey weeks in both May and September, it could be assumed that further surveys would yield few additional individuals, even though it is possible there were more young animals present in September than were detected. However, on the information available, population estimates of 40 hedgehogs in May and 50 hedgehogs in September would appear reasonable.

A population size of 50 hedgehogs falls within the range of 32 to 60 animals that Moorhouse (2013) suggested would represent a Minimum Viable Population (MVP) for hedgehogs in UK urban areas, based on modelling studies. These figures assume that urban habitats would provide high levels of food and shelter, low predation risk, low mortality rates, and a relative constancy in mortality and breeding rates from one year to the next. Although the hedgehogs at The Regent's Park clearly bred during the summer in 2014, there are no data available on breeding rates. The proportion of animals recaptured in September that were first captured in May, termed 'persistence', was reasonable in females (69%) but lower in males (38%). Approximately the same number of males and females were found in May, but fewer adult males than females were captured in September. It may be that this is a result of reduced male activity in the post-breeding period, or possibly males are at greater risk of mortality than females during the 15 week period from May to September, as a result of their more extensive movements associated with breeding activity. However, to address these differences between males and females in persistence and relative numbers, more in-depth studies across the summer would be needed. This would also apply to other times of the year, such as overwinter when it is likely that some animals will die during hibernation (Reeve, 1994). Perhaps, a priority for future studies would be to assess whether the population of hedgehogs in The Regent's Park is stable, increasing or decreasing from one year to the next. To make this evaluation, annual surveys in May and/or September over a number of years would be necessary.

The study was not able to confirm whether The Regent's Park population of hedgehogs was isolated. However, all hedgehog movements recorded were confined to the study area. DNA was successfully extracted from spines clipped from individual hedgehogs during the surveys (Catherine O'Reilly pers. com), and future studies using genetic markers to look at genetic variation within the population would be valuable, as well as using markers to identify individual animals.

The Regent's Park is 1.66 km^{-2} in area, and so a population of 40 animals would represent a density of 24 hedgehogs km^{-2}, and 50 animals, 30 hedgehogs km^{-2}. However, the distribution of hedgehogs within the Park was patchy and in particular we found that hedgehogs did not use the ~ 0.4 km^{-2} of sports fields. If this is taken in to account, adjusted densities would be 32 hedgehogs km^{-2} and 40 hedgehogs km^{-2} respectively. Hedgehogs were abundant in both the Zoo car park in the north east of the Park and Avenue Gardens in the south east. They were also present in the south and the west but few were found in the east and north. This patchy distribution warrants further investigation. Low numbers may be related to food availability, nest sites or disturbance and predation. Badgers (*Meles meles*) are significant predators of hedgehogs (Micol *et al.,* 1994; Young *et al.,* 2006; Hof *et al.,* 2012) and may contribute to the decline in their numbers in certain parts of the country. However, there are no badgers in The Regent's Park. Foxes (*Vulpes vulpes*) and dogs may kill hedgehogs, especially the young and sick (Morris & Reeve, 2008). Many foxes were seen to the north of the Park, but they undoubtedly roam everywhere. It could also be that hedgehogs avoid areas with high numbers of foxes because of excessive disturbance (see Hof *et al.,* 2012). It is also possible that foxes may have been responsible for the leg injuries found on several hedgehogs in May (see above), something that needs to be looked into further. Other animals that may disturb or kill hedgehogs include: domestic cats, brown rats (*Rattus norvegicus*) (Reeve, 1994). Road traffic accidents are known to be a significant mortality factor (e.g. Kristiansson, 1990; Reeve, 1994; Huijser & Bergers, 2000) but none was reported to us around The Regent's Park during 2014.

Animals tend to be patchily distributed in suburban and urban habitats (Prange *et al.,* 2004) and estimating population density can be problematic. In the case of hedgehogs, it depends on

sampling methodology, how the population is defined in time and space (Van Horne, 1983), how much green space is present (e.g. Micol *et al.*, 1994) and whether unsuitable areas are discarded from the estimates; we have looked at the effects of doing this above (see Hubert *et al.,* 2011). Clearly The Regent's Park is virtually all 'green space' and densities are not necessary comparable with hedgehogs in areas with medium to high density housing. Some years ago, Plant (1979 in Harris, 1995) gave a minimum density of 7.3 hedgehogs km^{-2} in East London based on sightings and road kills. Using distance-sampling methods, Hubert *et al.,* (2011) provide estimates of 36.5 ± 15.2 hedgehogs km^{-2} centred on the city of Sedan in north east France, and Berthoud (1982 in Hubert, 2011) found a density of 25 hedgehogs km^{-2} in Yverdon-les-Bains in Switzerland (methods used not known). These densities are broadly comparable to those found in this study. It has been suggested that as numbers of hedgehogs continue to decline throughout the wider countryside, urban and amenity areas with suitable environmental conditions may serve as significant refuge areas (Young *et al.,* 2006, Poel *et al.,* 2015).

7.3 Ectoparasites and injuries

The presence of hedgehog fleas and ticks increases the probability that the hedgehog population has been continuously present in the park and has not died out at any time. An unrecorded reintroduction of wild hedgehogs with ectoparasites could have taken place in the past, but animals released from rescue centres (the usual source of animals for release) will typically have lost fleas and ticks while in captivity. Whether or not anyone has released hedgehogs in the Park at any time is currently unknown.

A number of illnesses and injuries were recorded for eight animals in May, but none in September. Six of the eight had hind leg injuries with either amputation of the limb or multiple fractures. Two of these were old injuries and, as the animals seemed to be otherwise in good health, they were left in the field. However, two with severe injuries complicated by infections were euthanased by the ZSL veterinary surgeons and one of the study animals was found dead with multiple fractures to a hind limb. The isolation of the bacterium *Pasteurella multocida* from one of the leg wounds and the nature of the injuries suggests the cause to be predator attack but we have no conclusive evidence of this. The GPS data from the study animal that died suggest that the injury occurred in the middle of the night. Given the frequent sightings of foxes by the survey teams, we suggest that foxes are most likely to be the cause of these injuries. Why none occurred in September remains to be explained. Two of the hedgehogs had fly larvae in their ears. One had to be euthanased; the other was treated and released the next day but was also found to have an old healed forelimb fracture. One other sick animal died shortly after its discovery and was found to have a pulmonary infection and other co-morbidities.

7.4 Nest sites and behaviour

When the hedgehogs used inaccessible locations, nests could not be located precisely. However 29 nests were found and described for the 16 radiotracked hedgehogs. There was a clear preference for informal shrubbery (75% of sites); a habitat likely to provide less-managed, dense undergrowth to support and conceal nests. Formal shrubbery (14%) and hedge bases (11%) were also used suggesting that at least some of these did provide adequate nesting environments. Whether or not the availability of good nest sites is a limiting factor for this population cannot be determined by the present study, but a positive hedgehog conservation measure would be to ensure a good supply of suitable areas for hedgehogs to build nests throughout the Park.

Hedgehogs often move to another nest which is sometimes a newly constructed site, sometimes one previously used by that or another hedgehog. Reeve & Morris (1985) found that adult males changed nests on average every 3.0 days; every 9.6 days for adult females without litters. In the present study of two week-long periods, 45% used 2 and 5% used 3 nests, showing typical behaviour for hedgehogs also found in other studies (Reeve, 1994).

The behaviour of selected radiotracked hedgehogs was recorded every five minutes by volunteer observers using focal animal sampling on 25 occasions for periods of 10 minutes to one hour. In addition 21 single records of location and behaviour of hedgehogs were made. As well as revealing what the animals were doing, the aim was to show habitat use while engaged in behaviours such as foraging. Ideally, more data would have been gathered but of 176 behavioural records 34% were foraging, and 36% were locomotion. This was much lower than found in detailed studies by Wroot (1984) in similar habitat (suburban golf course) in which foraging was recorded 58-64% of the time. Such a difference might be due to observers finding it hard to distinguish slow locomotion (28% of records) from foraging, but additionally the 22% of fixes in which the subject was stationary suggests that there may have been some disturbance effect. Courtship was rarely recorded (3% of records); a good match to Wroot's study where it was 4% of records.

Habitat selection during foraging (60 records) appeared to be heavily biased towards grassland, especially short grass under 10 cm high (58% of records) and longer grass (23% of records). Informal shrubbery (15%) and base of hedge (3%) made up the remainder. Although the sample size is small, this does suggest that formal shrubberies and flower beds are not important foraging habitats. It is, of course, easier to see where a hedgehog is and what it is doing in short grass, therefore such data may be influenced by observer bias. Nonetheless, there is no doubt this is an important foraging habitat and the GPS tracking data tend to corroborate this 'preference' for short grass; although given the potential inaccuracy of GPS locations only visual confirmation can be used reliably to determine the habitat an animal is in (see below). Further work is needed to examine general behaviour as well as foraging habitat preference.

7.5 Nightly movement and home range

Without additional visual observations, GPS locations alone may be too imprecise to provide high reliability data on habitat utilisation patterns in a fine-scale mosaic of flowerbeds, shrubberies and grassland. Nevertheless, the GPS location error was directionally random and with a large number of fixes available, an analysis using Jacob's indices (Table 6.5) of the distribution of GPS locations in relation to the habitat areas within their ranges showed a strong preference for 'amenity grassland' – consistent with the observations of radio tracked animals (see above). It should be noted that no animals were observed on the sports fields and these habitats should not be confused with 'amenity' grassland. The same analysis also showed that the most avoided habitats were 'bare artificial habitat' and 'planted shrubberies and flowerbeds'. In habitats with dense cover the GPS tags may fail to contact enough satellites to log a location, so some under-representation of the use of habitats such as woodland and perhaps hedgerow would be expected.

Hedgehogs are usually nocturnal although some day-time activity is not unknown (Reeve, 1994). However, most radio tracking studies of hedgehogs cease monitoring during the day and, unlike GPS tags, are not designed to record day-time movements. As noted in the results above (6.6.3.), when in a nest and amongst undergrowth, the positional fix errors of the GPS tags are greater and this can give the illusion of activity. Nevertheless, some animals showed signs of genuine day time

movements and further work to verify day-time movements, ideally using conventional radio tracking, is necessary.

The GPS tracking revealed the nocturnal movements of hedgehogs in May and 10 hedgehogs in September. The mean distance travelled per night was 798 m (n=15), excluding one particularly wide ranging male (No.32) who moved on average 1897 m per night in May. Such distances are consistent with other studies of European hedgehogs (see Table 7.1). In contrast to other studies, we found no significant difference in distance travelled between the sexes males (n=6) and females (n=10). This is likely to be due to a small sample size, an unbalanced sex-ratio and a larger sample size late in the season. Generally, in spring and summer, significantly greater distances are travelled by sexually active males but late in the season males are no longer searching for receptive females (Reeve, 1994). In the present study, in May all of the four tagged males travelled further per night (range of means 697-1897 m) than the two females (range of means 637-662 m) during May. In September, only two of the eight tagged females travelled a shorter distance per night than the two males; three of the females exceeded 1000 m per night. At this time of year animals are seeking to maximise their fat stores prior to hibernation.

Time of year	Age/sex	Mean nightly distance (m)	N	Study notes and method used to estimate distance per night
Seasonal	M adult	1690	14	Reeve (1982): Britain.
	F adult	1006	8	Sum of minimum distances between fixes.
	M/F subad.	1188	9	Seasonal total
June	M adult	1761	19	Kristiansson (1984): Sweden
August	F adult	782	21	Calculated values from average speeds and activity duration.
	M adult	1013	29	
	F adult	974	30	
August/Sept	M adult	1158	17	Morris (1985a): Britain
	F adult	660	13	Sum of minimum distances between fixes.
July/August	M adult	868	11	Morris (1986): Britain
	F adult	570	12	Sum of minimum distances between fixes.
	F adult (lactating)	693	10	
July/August	M adult(old)	1785	19	Morris (1988b): Britain
	M adult	933	9	Sum of minimum distances between fixes.
	F adult	957	17	
Summer (no details)	M adult	1417	--	Dowie (1987): Britain. Sum of minimum distances between fixes. Mixed farmland & pasture (Kent).
	F adult	915	--	
	M adult	328	--	Pasture (Gloucestershire).
	F adult	471	--	

Table 7.1 Average nightly distance travelled in six studies of hedgehogs reviewed by Reeve (1994: Table 4.2)

8. Main conclusions and recommendations:

8.1 The organisation and management of this partnership project was very successful. With the participation of 68 volunteers the study yielded a great deal of data, giving us new information about this previously unstudied hedgehog population.

Recommendation 1 The current project partnership and volunteer recruitment provides a successful model for any further studies and should be continued.

8.2 The hedgehog population is small and vulnerable. A population in the region of 50 individuals is within the lower range of a minimum viable population calculated for a site of this size. The vulnerability to local extinction would be increased by any negative impacts especially affecting any of the three hedgehog 'hotspots': Zone 1 the Avenue Gardens and Marylebone Green, Zone 2 the area around the ZSL car park, and Zone 5 Queen Mary Gardens and the area around the Lake.

Recommendation 2 Risk to hedgehogs should be an integral factor in evaluating any management procedures or changes of use. This should apply to the whole park but the 'hotspots' identified should be particularly safeguarded.

Recommendation 3 Spotlighting surveys to provide systematic counts of hedgehogs should be repeated regularly to establish whether or not this may be a declining population. Initially the survey should be repeated in both May and September 2015, but could be reduced to a single survey period – most likely in September so that successful breeding can be detected. The survey should be repeated annually until a trend is established and then the survey frequency reviewed.

Recommendation 4 If future surveys indicate that the population is at risk then further research may be appropriate to identify the causes of population decline e.g. over-winter mortality or a lack of a key resource. Remedial measures should be implemented as a matter of urgency and, if appropriate, consideration given to population augmentation.

8.3 Given the vulnerability of this population, further work on the genetics and level of spatial isolation of the population is particularly important. Additional survey work to establish presence or absence of hedgehogs in nearby green spaces, particularly Primrose Hill is also recommended.

Recommendation 5 The degree of spatial and genetic isolation of the hedgehog population should be investigated as a priority to inform future management.

8.4 The population appears to be a wild relict population, as evidenced by the presence of hedgehog-specific ectoparasites. However, we have no information as to whether hedgehogs (either wild-caught or released captives) may have been brought to the park from other sites.

Recommendation 6 Enquiries should be made of organisations, residents and neighbours of the park (see also Recommendation 8.9 below) to find out whether anyone knows of hedgehog translocations or other interventions that may have occurred.

8.5 The combined use of VHF radio tracking and GPS tags was successful in revealing the ranging behaviour and movements of a total of 16 hedgehogs. Ranging behaviour as revealed by the data from GPS tags was, in terms of both nightly distance-travelled and the area covered each night, normal for the species and consistent with other studies of European hedgehogs. The limited accuracy of GPS location fixes highlighted the need for nest locations to be verified by radio tracking on foot and for direct behavioural observations to determine habitat use patterns.

Recommendation 7 Future studies of hedgehog behaviour should use VHF radio tracking to verify and augment data from GPS tags.

8.6 Foraging habitat. Both direct observation and GPS data agree on the importance of grassland, especially Amenity Grassland, as foraging habitat. Hedgehogs were never recorded as visiting the sports pitches and made almost no use of the open grassland on Cumberland Green or Gloucester Green, although Marylebone Green was heavily used. We conclude that large areas of open grassland (especially if intensively managed) are avoided by hedgehogs but that grassland within a fine-scale mosaic of formal and informal shrubberies and hedges is an important resource.

8.7 Nest sites were mainly found in informal shrubberies (75% of nests), although some use of hedge bases and formal shrubberies was also recorded. This highlights the importance of providing suitable nesting habitat throughout the year and ensuring that hedge bases, formal shrubberies and other habitats where possible are managed with hedgehog nesting in mind.

Recommendation 8 In order to protect and increase the provision of nest sites and foraging habitat (8.6 & 8.7 above) and to minimise hazards to hedgehogs, some detailed management recommendations are provided in Appendix 9. We recommend that TRP staff and contractors, and those from other organisations within the park, are made fully aware of these recommended actions, the vulnerability of this hedgehog population, and offered suitable additional training as necessary such as the PTES training for land managers and consultants. Records of management changes should be kept and reported to allow the potential effects of such changes on the hedgehog population to be monitored.

Recommendation 9 More focused follow-up radio tracking studies of nesting and behaviour would allow more detailed analyses of hedgehog habitat requirements that would further inform habitat management. Comparative studies of invertebrate prey availability in different parkland habitats would also increase understanding of their biodiversity value and allow the monitoring of changes in invertebrate prey abundance as a result of management change.

8.8 The hedgehogs found were generally in good condition with above average body weights. Finding some illnesses among a wild population is to be expected although none was found in the September survey. In May, six animals with problems typical of wild hedgehogs were referred to veterinary surgeons. One was re-released after treatment of an ear infection. However also in May, seven hedgehogs presented with right hind leg fractures or amputations, four of which had healed, but three of which were fatal injuries. The cause of these injuries is unknown but predator attack is one possibility.

Recommendation 10 As a precaution, care should be taken to consider and avoid all possible causes of such injuries that could result from human action. The number and location

of fox dens should be recorded and fox sightings should be recorded in order to estimate the number of foxes on the site and their distribution.

8.9 Further community engagement is desirable to raise the awareness of the importance of wildlife conservation among residents and neighbours of the park. This may have many benefits in encouraging wildlife-friendly behaviour and increasing the perceived value of the park for local stakeholders. Local residents are also an important source of information, and may contribute hedgehog records from gardens (etc.) or road kill, and may volunteer for future studies.

Recommendation 11 That an information leaflet be created and distributed to local residents, providing information about hedgehogs in the park and inviting them to contribute information to an on-line survey.

8.10. The study provides information and recommendations that are interest to a wider audience, both public and professional. The findings may help other urban park managers to manage their sites in a 'hedgehog-friendly' way so as to conserve vulnerable and declining populations of this popular mammal; a UK priority species for conservation.

Recommendation 12 The study outcomes should be disseminated to a wider audience, including ecology and land management professionals. Suitable media could include both printed and internet documents, the use of on-line social media, educational work with schools, Hedgehog Street campaign within London, presentations to the public and professional forums with a call to action to support the hedgehogs of Regent's Park.

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Every one of the wonderful 68 volunteers who gave up their evenings to help us track the elusive hedgehogs of The Regent's Park

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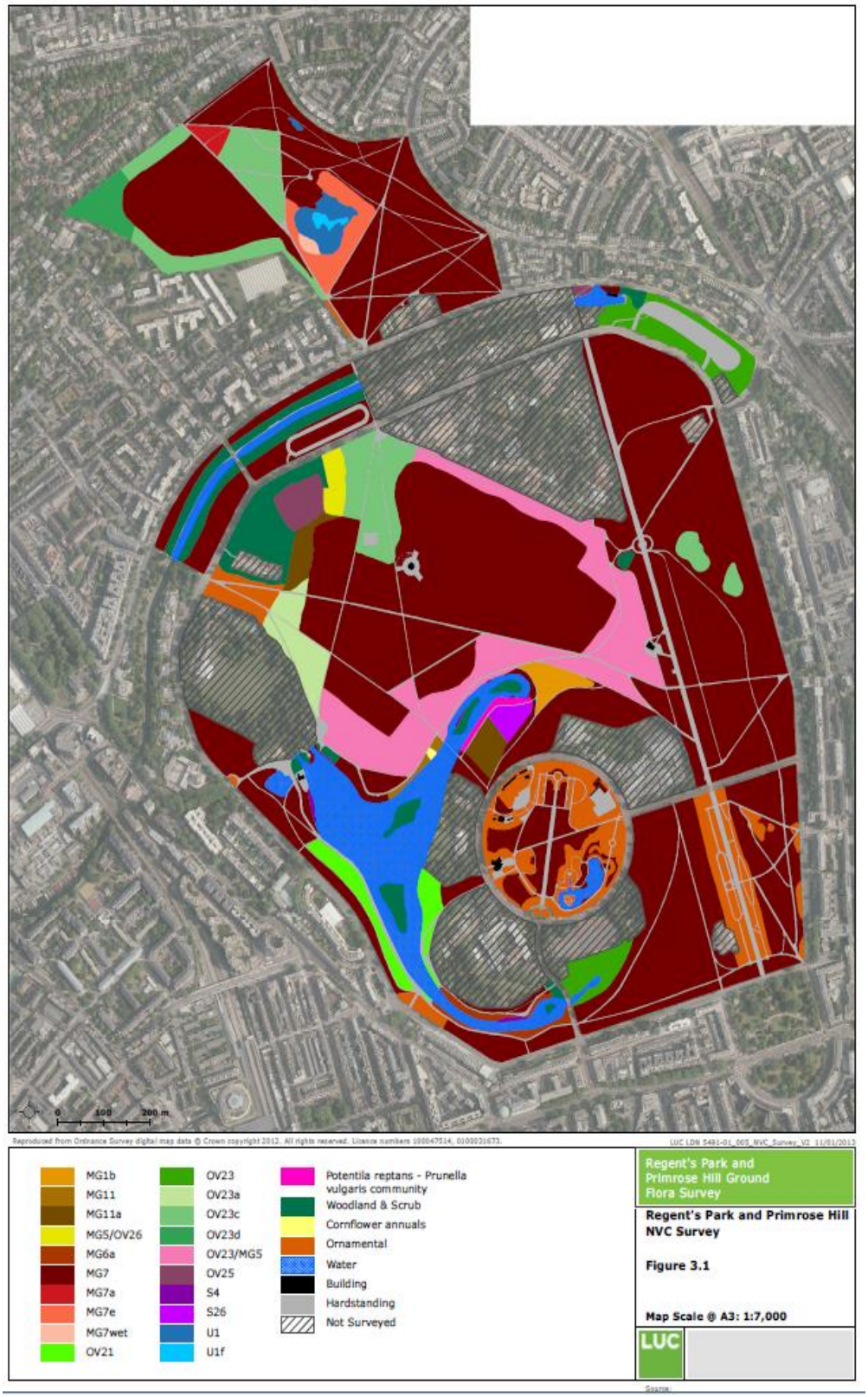
Appendices

Appendix 1 Equipment list for The Regent's Park Hedgehog Research Project, 2014

Spotlighting	LED Lenser handheld torch
	Handheld torches
	AA & AAA batteries
Marking	Garmin handheld GPS tracker
	Salters Spring balance (super samson)
	Coloured electrical sleeving
	Measuring tape
	Super glue
	Tweezers
Volunteer welfare	High visibility jackets
	Headtorches
	Walkie Talkies
	Cleaning wipes
Footprint tunnels	Footprint tunnels
	Pegs
	Masking tape
	Vegetable oil and powder paint
	Ream of A4 paper
	Tinned hot dog sausages
	Mammal Sociaety footprint recognition guide
Camera traps	Bushnell HD Trophy Cameras
	SD memory cards
	Garden wire and cables
	Padlocks
Radio tracking	TW-5 tags plus mortality sensors
	Receivers (Sika, TRX, Mariner)
	Flexible 3 element Yagi aerial
	Headphones
GPS tags	igotu GPS transmitters
	Superglue
	Cable cutters

Appendix 2 Map of the ground flora communities of The Regent's Park and Primrose Hill (source: LUC, 2013)



MG1 – Neutral grassland – semi-improved
MG11 – Marginal inundation
MG5 – Neutral grassland unimproved
MG6 – Neutral grassland semi improved
MG7 – Improved grassland
OV11 – Cultivated / disturbed land
OV23 – Amenity grassland
OV25 – Tall herb and fern
S4 / S26 – Swamp
U1 – Acid grassland

HEDGEHOG research project IN THE Regent's Park

Volunteer SURVEY GUIDE May 2014

Lead Partners

THE ROYAL PARKS

ZSL LIVING CONSERVATION

THE ROYAL PARKS FOUNDATION

Ancillary Partners

People's Trust for Endangered Species **Untyped** **Central Royal Parks Wildlife Group**

Contents

1. Project Summary

What we're doing

In 2014 we are running a Hedgehog Research Project in The Regent's Park, which aims to provide information on the status of hedgehogs in the Park: how many there are, which habitats they use and whether the population is sustainable. Hedgehogs are a UK Biodiversity Action Plan (BAP) priority species and The Royal Parks is a lead partner in the BAP for Westminster.

We will be carrying out a general survey and an intensive behavioural study on The Regent's Park and London Zoo grounds in May and September 2014. In spring 2015, we will share our findings and recommendations in a report. We will also be running a wider programme of educational outreach from 2014 to 2016 to raise awareness of hedgehogs living in green urban areas.

Using the research findings, we will recommend ways to manage habitats within the Park to be more sympathetic to hedgehogs, which may also help wildlife conservation in other urban open spaces.

Who's involved?

This Project is a partnership that brings together the Royal Parks Foundation, The Royal Parks, the Zoological Society of London (ZSL), and expert wildlife biologists Dr Nigel Reeve and Professor John Gurnell. The survey and study will be supported by a team of volunteers, ecology students and local neighbours with a keen interest in wildlife and conservation.

Also supporting the survey are our current ancillary partners, People's Trust for Endangered Species, Untyped and the Central Royal Parks Wildlife Group, organisation that seeded the idea of this research project with Dr Nigel Reeve a few years ago.

What else we hope to achieve

Using education, community engagement and a communications campaign, we hope to inspire local people to take a greater, active interest in urban wildlife conservation. We also hope to positively affect the future conservation and education work of The Royal Parks, ZSL and the Royal Parks Foundation.

2. About Hedgehogs

Hedgehogs were once common and familiar animals in rural and suburban British landscapes but there is evidence from a number of sources of a significant and general decline in numbers in recent years. Several factors have been put forward as reasons for this decline:

- Predation, especially by badgers in areas with high badger densities
- Death from traffic on roads or being killed in bonfires
- Changes in agricultural practice and a reduction in invertebrate food availability
- Fragmentation of habitat
- In gardens, the absence of garden compost/wood piles/leaf litter for hibernation sites and the use of fences without movement gaps rather than hedges. Also drowning in garden ponds without escape ramps
- Becoming trapped in cattle grids or becoming caught in discarded cans, and other debris

The presence of hedgehogs in London's central Royal Parks mirrors this national decline; in the early 1970s they were found in all the Parks, but since then they have disappeared from all except The Regent's Park. This questions was raised by Central Royal Parks Group

However, explanations for the loss of hedgehogs are circumstantial and there is a lack of direct scientific evidence about the true extent, scale and causes of the hedgehog decline. This applies as much to London's Parks as to the wider countryside. So, why are hedgehogs able to persist in The Regent's Park and not elsewhere, and what can be done to ensure they survive into the future? This project directly addresses these questions and from the findings will draw up habitat management recommendations for The Regent's Park that may also be applied to other urban open spaces.

Since 2007 hedgehogs have been a UK Biodiversity Action Plan (BAP) priority species and also a Westminster BAP species for which The Royal Parks is a lead partner.

Scientific benefits of this survey

By carrying out a series of carefully designed, mutually compatible surveys using different methodologies that focus on the population as a whole down to individual hedgehogs in The Regent's Park, detailed scientific measurements on numbers, demography, habitat use and movement of these endangered animals will be obtained for the first time. The study will provide valuable insights into why hedgehogs are able to persist in The Regent's Park and not elsewhere, and what can be done to ensure they survive into the future. The following methods will be used: footprint tunnels, spotlighting, GPS and radio tracking, as well as camera trapping.

Developing habitat management recommendations

This unique study will provide a more detailed understanding of which features and areas of the Park (and its surroundings) are used by hedgehogs and how they use them. This information will be reviewed in the light of our existing understanding of hedgehog habitat requirements to develop

detailed recommendations for conserving hedgehogs in the Park and its surroundings. The results will also inform the management of other urban open spaces.

3. Survey Activities Overview

You will find a more detailed guide for each activity you're volunteering on in the back of your pack.

A. Footprint Tunnels

Footprint tunnels are plastic tunnels which are baited up and house ink pads and clean paper. The hedgehog will be attracted to the tunnel by the bait and as they move through the tunnel, ink pads copies of its footprints will be left on the paper. This activity helps us map areas of the Park where hedgehogs are particularly active, so will help guide the second week of our survey. Volunteers will help place footprint tunnels in specific areas of interest in Regent's Park over the course of the week. Each tunnel will be checked daily to ensure it is still standing, whether there are any footprints and replace ink pads, paper and bait as needed. We will have 3 teams of volunteers each day and 60 tunnels to check.

B. Spotlighting & GPS

This is a general nocturnal survey carried out by teams of volunteers with the aim to help provide hedgehog population estimates in the Park. Volunteers will be tasked to find active hedgehogs by torchlight, make notes on its health and condition, then mark them with plastic markers on the spines so we can identify each hedgehog for the rest of the survey. Some hedgehogs will also be fitted with GPS and radio tracking packs to gain more detailed behavioural data. This will be followed by a second session a week later to count the numbers of marked and unmarked hedgehogs and remove the tracking packs.

C. Radio Tracking

Volunteer teams, led by a supervisor will observe hedgehog movement and behaviour on specific hedgehogs over seven consecutive nights. The teams will obtain detailed observations by using radio tracking equipment to find an individual hedgehog then follow it for circa 30-60 minutes noting its activity, area of the Park it's using and any general observations. Teams will follow 2-4 hedgehogs each night depending on how many hedgehogs are fitted with radio packs during the spotlighting survey.

D. Camera Trapping

This activity involves the installation and maintenance of 10 cameras across Regent's Park. Volunteers will help to position the cameras on the first day of the survey and will check the cameras each day to check they are still in position, working well and replace the memory cards to ensure sufficient storage space on the camera for the next night. The data from the memory cards will then be downloaded on to a computer and saved securely.

4. Hedgehog Survey Fortnight – Key Dates & Activities (contingency w/c 2 June)

			Week 1							Week 2						
Activity	Team	Zone	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun
			1	2	3	4	5	6	7	8	9	10	11	12	13	14
			19 May	20 May	21 May	22 May	23 May	24May	25May	26May	27May	28May	29May	30May	31May	1 June
1. Footprint Tunnels	a	1	Place	Check 1	Check 2 Remove											
		2			Place	Check 1	Check 2 Remove									
	b	3	Place	Check 1	Check 2 Remove											
		4			Place	Check 1	Check 2 Remove									
	c	5	Place	Check 1	Check 2 Remove											
		6			Place	Check 1	Check 2 Remove									
2. Spotlighting & GPS Tracking	d	1					Packs attached							Packs removed	Reserve	Reserve
	e	2					Packs attached							Packs removed	Reserve	Reserve
	f	3					Packs attached							Packs removed	Reserve	Reserve
	g	4					Packs attached							Packs removed	Reserve	Reserve
	h	5					Packs attached							Packs removed	Reserve	Reserve
	i	6					Packs attached							Packs removed	Reserve	Reserve
3. Radio Tracking	j	1 & 2					Packs attached	Track	Track	Track	Track	Track	Track	Packs removed	Reserve	Reserve
	k	3 & 4					Packs attached	Track	Track	Track	Track	Track	Track	Packs removed	Reserve	Reserve
	l	5 & 6					Packs attached	Track	Track	Track	Track	Track	Track	Packs removed	Reserve	Reserve
4. Camera Trapping	m	1, 2 & 3					Position	Check	Check	Check	Check	Check	Check	Remove	Reserve	Reserve
	n	4, 5 & 6					Position	Check	Check	Check	Check	Check	Check	Remove	Reserve	Reserve

5. The Regent's Park Maps

We have divided the Regent's Park into 7 zones, as follows:

Zone 1	Marylebone Green, Avenue Gardens, Community Wildlife Gardens, Tennis courts
Zone 2	Cumberland Green, Gloucester Green, Zoo car park
Zone 3	Sports pitches
Zone 4	Back of nursery, St John's lodge garden, Wetland area, Long Bridge
Zone 5	Hanover green, water side, Holme Green, Queen Mary's Gardens
Zone 6	Edge of lake, Winter Gardens, Running track, leafyard wood
Zone 7	ZSL London Zoo

You can see these zones clearly marked in the Visitor's Map provided.

A map of zones 1- 6 (in A4) is also provided with a suggested trail to follow, in particular for the Spotlighting activity.

Detailed maps of each area will be located at Hedgehog HQ and given to each group supervisor.

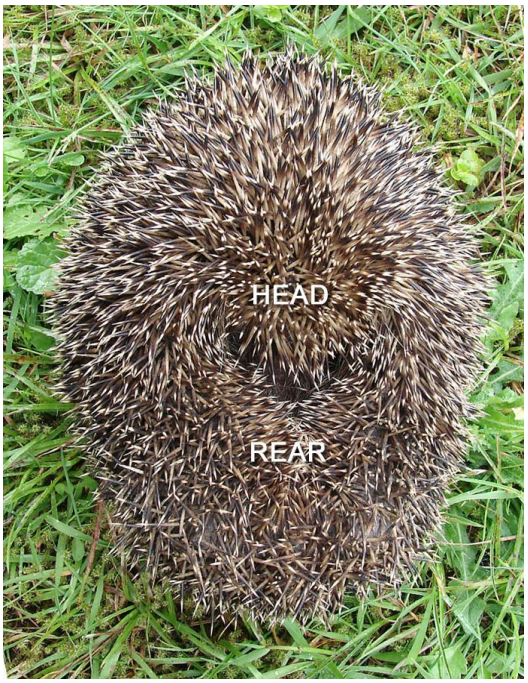
6. How to Handle a Hedgehog

As part of some of the survey activities, we are hoping we will come into contact with hedgehogs in the Park. If you are happy and confident to, there may be the opportunity to handle a hedgehog. Your project supervisor will be able to assist you.

Always wear gloves. Hedgehogs rarely bite but are prickly and normally very dirty. During handling, be quiet and avoid rustling or clicking noises, don't make what you might think of as reassuring noises like tutting or shushing. Use hand-sanitizing gel or wash your hands after handling them.

When you pick up a wild hedgehog it will usually roll-up into a ball. To examine it you need to get it to unroll. Various methods exist but this one is relatively easily taught and usually successful. Some individuals are very reluctant to unroll and it can take many minutes just to determine the sex of the animal. The technique (for a right handed person) is as follows:

Gently pick up the hedgehog and hold it face down so that its rear-end is in your right palm and your left hand is under its front end (nose pointing away from you). Gently bounce it up and down in your hands, with luck it will gradually put out its feet and untuck its snout - now you have a crouching hedgehog. Without hurrying, keep bouncing it gently and allow the snout to poke between the thumb and index finger of the left hand and, using gentle but firm pressure, place the thumb on the back of its neck. Now it cannot tuck its head back down. Gently gripping the underside at the rear of the animal with your right fingers, put your right thumb in the small of its back and gently open out the animal by flexing it backwards; keep all movements smooth and slow.

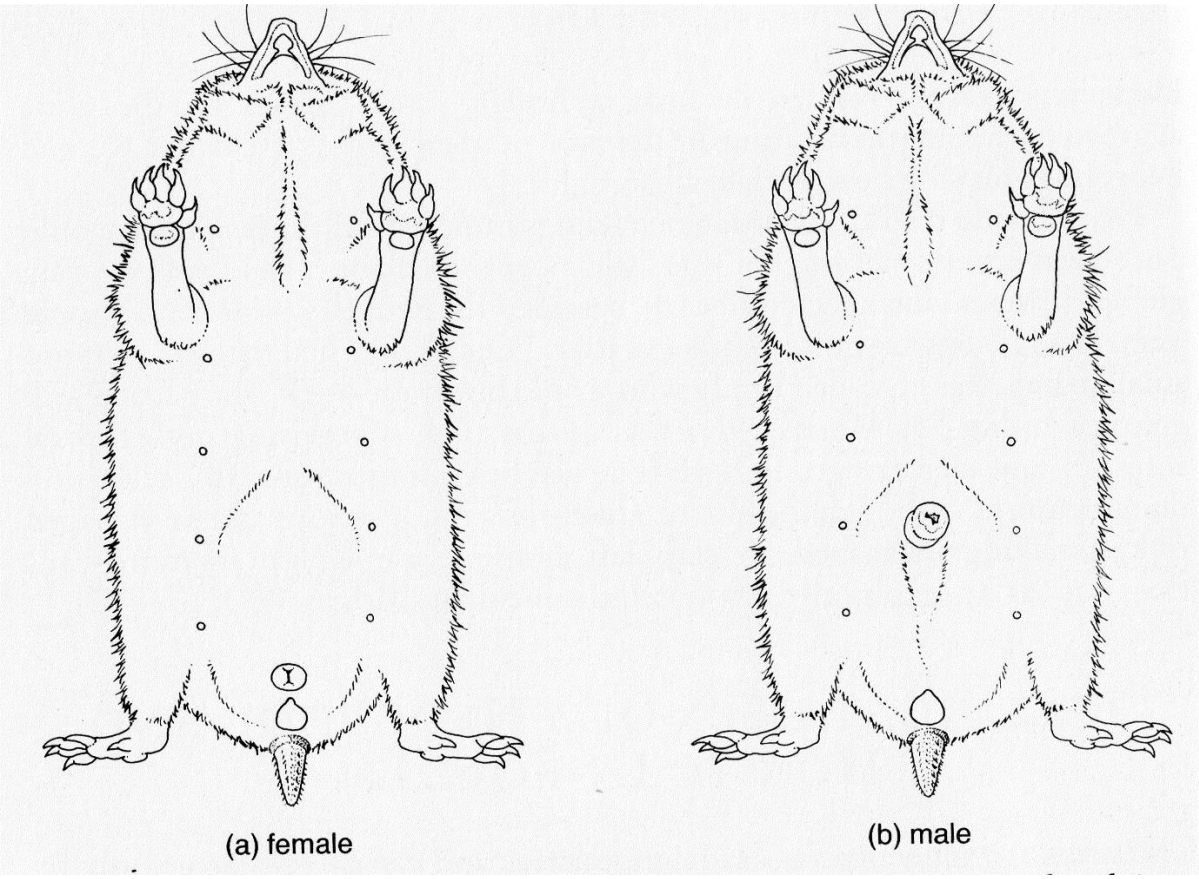


A rolled-up hedgehog on its back.

A wild-caught hedgehog unrolled in the hand.

The sexes can only be told apart by inspecting their genitalia. Luckily the differences are obvious. The male has a conspicuous penis sheath opening well forward on the belly (roughly where one might expect to see the navel), whereas the vulva of the female is very close to the anus. Although the male's testes are abdominal, there is a visible bulge in mature animals. Up to 10 nipples are visible in both sexes, but in pregnant or lactating females they may be more prominent.

If an animal will not unroll in the hand, lay it on its back on the ground. Wait quietly until it begins to unroll. Just as the animal rights itself (as if to run away) it will open up and you stand a good chance of seeing the underside. Because the penis sheath is usually obvious, you can usually determine the sex.



Drawing of the undersides of the two sexes. Source: p. 42 in Reeve N. J. (1994) Hedgehogs, Poyser

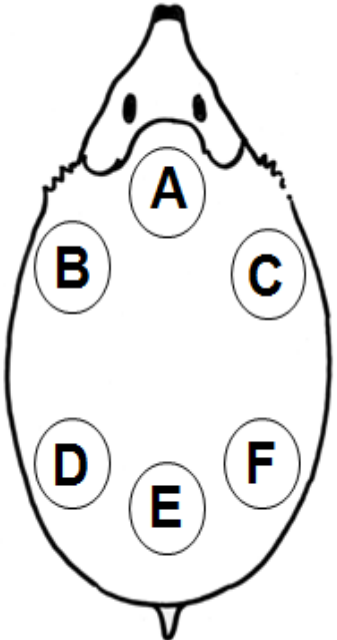
7. Hedgehog Marking System

During the spotlighting activity we will capture and mark the hedgehogs we encounter. Hedgehogs will be marked using short lengths of coloured plastic tubing. The marking system below outlines how we will mark the hedgehogs so we can tell which number it is and which zone it was originally found in.

Zone	Animal No.	Animal No.	A	B	C	D	E	F
1	1	13	BLUE					
1	2	35	BLUE	BLUE				
1	3	36	BLUE		BLUE			
1	4	37	BLUE			BLUE		
1	5	38	BLUE				BLUE	
1	6	39	BLUE					BLUE
1	7	50	BLUE	WHITE				
1	8	51	BLUE		WHITE			
1	9	52	BLUE			WHITE		
1	10	53	BLUE				WHITE	
2	11	54	BLUE					WHITE
2	12	75	BLUE	RED				
2	13	76	BLUE		RED			
2	14	77	BLUE			RED		
2	15	78	BLUE				RED	
2	16	79	BLUE					RED
2	17	80	BLUE	YELLOW				
2	18	81	BLUE		YELLOW			
2	19	82	BLUE			YELLOW		
2	20	83	BLUE				YELLOW	
2	21	84	BLUE					YELLOW
3	22	1	RED					
3	23	25	RED	RED				
3	24	26	RED		RED			
3	25	27	RED			RED		
3	26	28	RED				RED	
3	27	29	RED					RED

Zone	Animal No.	A	B	C	D	E	F
5	54	YELLOW					
5	55	YELLOW	YELLOW				
5	56	YELLOW		YELLOW			
5	57	YELLOW			YELLOW		
5	58	YELLOW				YELLOW	
5	59	YELLOW					YELLOW
5	60	YELLOW	WHITE				
5	61	YELLOW		WHITE			
5	62	YELLOW			WHITE		
5	63	YELLOW				WHITE	
6	64	YELLOW					WHITE
6	65	YELLOW	RED				
6	66	YELLOW		RED			
6	67	YELLOW			RED		
6	68	YELLOW				RED	
6	69	YELLOW					RED
6	70	YELLOW	BLUE				
6	71	YELLOW		BLUE			
6	72	YELLOW			BLUE		
6	73	YELLOW				BLUE	
6	74	YELLOW					BLUE
Spare	75	WHITE					RED
Spare	76	WHITE	BLUE				
Spare	77	WHITE		BLUE			
Spare	78	WHITE			BLUE		
Spare	79	WHITE				BLUE	

3	28	45	RED	WHITE				
3	29	46	RED		WHITE			
3	30	47	RED			WHITE		
3	31	48	RED				WHITE	
4	32	49	RED					WHITE
4	33	90	RED	BLUE				
4	34	91	RED		BLUE			
4	35	92	RED			BLUE		
4	36	93	RED				BLUE	
4	37	94	RED					BLUE
4	38	95	RED	YELLOW				
4	39	96	RED		YELLOW			
4	40	97	RED			YELLOW		
4	41	98	RED				YELLOW	
4	42	99	RED					YELLOW
Zoo	43	7	WHITE					
Zoo	44	30	WHITE	WHITE				
Zoo	45	31	WHITE		WHITE			
Zoo	46	32	WHITE			WHITE		
Zoo	47	33	WHITE				WHITE	
Zoo	48	34	WHITE					WHITE
Zoo	49	60	WHITE	RED				
Zoo	50	61	WHITE		RED			
Zoo	51	62	WHITE			RED		
Zoo	52	63	WHITE				RED	
Zoo	53		WHITE					RED

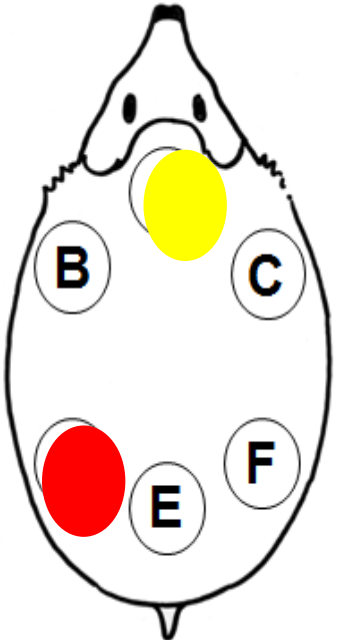


Locations for ID marks.

A: Crown of head
B: Left shoulder
C: Right shoulder

D: Left hip
E: Middle rear back
F: Right hip

Spare	80	WHITE					BLUE
Spare	81	WHITE	YELLOW				
Spare	82	WHITE		YELLOW			
Spare	83	WHITE			YELLOW		
Spare	84	WHITE				YELLOW	
Spare	85	WHITE					YELLOW
Spare	86		RED				
Spare	87			RED			
Spare	88				RED		
Spare	89					RED	
Spare	90						RED
Spare	91		WHITE				
Spare	92			WHITE			
Spare	93				WHITE		
Spare	94					WHITE	
Spare	95						WHITE
Spare	96		BLUE				
Spare	97			BLUE			
Spare	98				BLUE		
Spare	99					BLUE	
Spare	100						BLUE
Spare	101		YELLOW				
Spare	102			YELLOW			
Spare	103				YELLOW		
Spare	104					YELLOW	
Spare	105						YELLOW



Locations for ID marks.

A: Crown of head
B: Left shoulder
C: Right shoulder

Example Hedgehog, number 67...

D: Left hip
E: Middle rear back
F: Right hip

8. Hedgehog First Aid

Nic Masters, Head of Veterinary Services at ZSL, has provided a veterinary first aid plan for the Hedgehog survey, in case any hedgehogs found require veterinary attention. The plan is based on three scenarios, your project supervisor will be able to help you if a hedgehog does need veterinary attention:

1. Moribund or severely injured hedgehog (e.g. Road Traffic Accident or dog attack) requiring euthanasia.
2. Hedgehog with minor issue (e.g. constriction injury to limb) that can be treated effectively with immediate first aid and then released at exactly the same site.
3. Hedgehog with more serious issue that requires temporary hospitalisation followed by either release within a few days at exactly the same site, or rehoming in a rescue centre (agreed beforehand) within a few days.

Types of injuries you may encounter:

- Missing or injured eyes from contact with thorns etc
- Torn ears
- Bites or grazes on the hedgehog's side flanks
- Missing limbs
- Skin diseases
- 'Fly blown' wounds (an infected wound, looks like little grains of rice which are fly eggs)

Key contacts during survey:

Nic Masters has arranged the following veterinary support if a hedgehog that needs attention is found:

Friday 23rd May	Nic Masters (ZSL)
Saturday 24th May to Thursday 29th May	Fionah Wells (Practice Manager in Elizabeth Street Veterinary practice - Victoria)
Friday 30th May	Heather MacIntosh (ZSL)

Hospitalisation and care:

Hospitalisation services	ZSL London Zoo or Elizabeth Street practice
Rehabilitation services	Sue Kidger (Twickenham)
Friday 30th May	Heather MacIntosh (ZSL)

9. Data Management

A. Collecting and Storing Data

Data is an essential part of this project and it's critical we collect and store it so the results can be analysed to meet the objectives of this project. To make it as easy as possible for everyone, we're using two online platforms to store data for the survey – Cartographer and Dropbox.

Not all volunteers will need to add data into these platforms. Some of you may pass your data onto a supervisor so they can add it. Don't worry; your supervisor will give you instructions at the beginning of your activity on what you will need to do.

Whether or not, you will be adding data, it's important that you know how to use Cartographer and Dropbox as you will be able to view data collected, which should be interesting for everyone involved!

Cartographer

What is it?

Cartographer is an online platform which securely manages and stores survey data which has been collected and manually inputted by individuals and groups. The platform has been specifically designed to store data collected as part of environmental projects.

Who will be using it?

All volunteers will be given access to Cartographer so you can all see the data after it has been added. But not all volunteers will need to add data as some survey results will need to be added by the supervisors.

What will it be used for?

Volunteers WILL use Cartographer to enter data from the following surveys:

- Footprint Tunnels
- Spotlighting
- Camera Trapping (data about the video will be added, the files themselves will be added to Dropbox by supervisors only)

Volunteers WILL NOT use Cartographer to enter data from the following surveys:

- GPS Tracking (data collected will be entered into Dropbox by supervisors only)
- Radio Tracking (data collected will be entered into Cartographer by supervisors only)

How do i use it?

To enter and/or view data collected:

- Visit www.SupportTheRoyalParks.org/hedgehogs
- Click on link directing volunteers to enter/view the data
- Log in using your username and password
- Enter in your results
- Log out

Please see 'How to use Cartographer' for detailed instructions on how to input data into Cartographer.

Dropbox

What is it?

Dropbox is an online service that lets you share photos and videos. We are using it as it has the capacity to store lots of large files, such as videos and photos which we need for the camera trapping part of the survey.

Who will be using it?

All volunteers will be given access to Dropbox to see results from the surveys, such as videos from the camera tracking, but WILL NOT need to add data. Supervisors will be responsible for adding data to Dropbox.

What will it be used for?

Volunteers WILL NOT use Dropbox to enter data from any of the surveys. They will pass data collected from the following surveys to supervisors:

- GPS Tracking (Data collected will be entered into Dropbox by supervisors only)
- Camera Trapping (Video files will be added into Dropbox by supervisors only)

Detailed instructions on how to view data collected and stored in Dropbox will be sent to all volunteers before the survey starts.

B. Who is collecting & entering data and how?

Volunteers and supervisors will be entering data collected whilst out in the field, but depending on which activity you are taking part in will depend on if, when and how you need to enter data. To be clear, please find a list of survey activities below and see how you're involved.

Footprint tunnels

Volunteers:

- Complete proforma(s) whilst out in the field
- Enter data from proforma(s) into Cartographer when at a computer

Supervisors:

- Approve data entry in Cartographer for inclusion in analysis
- Store original papers from volunteers

Spotlighting

Volunteers:

- Complete proforma(s) whilst out in the field
- Enter data from profroma(s) into Cartographer when at a computer

Supervisors:

- Approve data entry in Cartographer for inclusion in analysis

GPS tracking

Volunteers:

- Assist Supervisors to attach GPS tracking packs to Hedgehogs
- DO NOT add data onto Cartographer or Dropbox
- DO need to pass on trackers to supervisors, if situation arises

Supervisors:

- At the end of the GPS survey, download the CSV's from trackers and upload onto Dropbox

Radio tracking

Volunteers:
Complete Proforma(s) whilst out in the field and pass onto supervisors

Supervisors:
Add data from proforma(s) to Cartographer and approve data for analysis

Camera trapping

Volunteers:

- Complete Proforma(s) whilst out in the field and pass onto supervisors
- Pass on SD card to supervisors, where appropriate

Supervisors:

- Approve data on Cartographer for inclusion in analysis
- Upload videos to Dropbox

C. Summary of Data Collection and Storage

Activities	Personnel	Dropbox	Cartographer	Notes
Footprint tunnels	Volunteer	No	Complete proforma(s) whilst out in the field and enter data from profroma(s) into Cartographer when at a computer	Volunteers will identify footprints from paper when back at HQ and hand them to supervisor at end of session Volunteers will sign out the number of proformas completed and take home to input into Cartographer and then return to the Royal Parks Foundation by S.A.E or scan and email
	Supervisor	No	Approve data entry in Cartographer for inclusion in analysis	
Spotlighting	Volunteer	No	Complete proforma(s) whilst out in the field and enter data from profroma(s) into Cartographer when at a computer	Volunteers will sign out the number of proformas completed and take home to input into Cartographer and then return to the Royal Parks Foundation by S.A.E or scan and email
	Supervisor	No	Approve data entry in Cartographer for inclusion in analysis	
GPS tracking	Volunteer	No	N/a	None
	Supervisor	At the end of the GPS survey, download the CSVs from trackers and upload onto Dropbox	No	
Radio tracking	Volunteer	No	No	Volunteers will hand in their completed proformas to the supervisor at the end of the session
	Supervisor	No	Add data from proforma(s) collected by volunteers to Cartographer and approve data for analysis	
Camera trapping	Volunteer	No	No	Volunteers will hand in their completed proformas to the supervisor at the end of the session
	Supervisor	Upload videos from SD cards	Add data from proforma(s) to Cartographer and approve data for analysis	

10. Volunteer Kit List

Volunteers will need to bring the following items with them to each session:

- Appropriate clothing for the activity:
    - Stout walking shoes
    - Sun hat if warm
    - Warm clothing for nocturnal activities
    - Wet weather gear if needed
    - Change of clothes if wet *(particularly a change of socks!)*
    - Where possible, please wear non 'rustly' clothing as hedgehogs don't like this noise

- Mobile phone

- Water bottle

- Snacks if you feel you might need them *(light refreshments will be available at HQ)*

- Camera *(if possible, particularly if you have night vision)*

- Volunteer Survey bag including *(you will be provided with this and the contents):*
    - Notepad
    - Pencil
    - Pen
    - Torch
    - Rain poncho
    - Lanyard
    - Volunteer ID card
    - Journaling form

11. Risk Assessment

A Risk Assessment for the Hedgehog Survey can be found in the back of your pack. Please ensure you read this ahead of your first volunteer session.

12. Hedgehog Headquarters (HQ)

Location

Hedgehog HQ is based at the Ironworks Building on the Inner Circle Regent's Park *(please see map in the back of your pack)*. Look out for the Hedgehog on the gate to find us!

Security & Access

Hedgehog HQ will be accessible during the times and dates of all survey activities. Hedgehog HQ will be locked at all other times.

You will need to sign in and out of each volunteer activity session at Hedgehog HQ, so we know you have entered and left the Park safely!

Facilities

Hedgehog HQ will have:

- Toilets
- Access to water
- Tea, coffee and light refreshments
- First aid and welfare items
- Location to store your personal belongings whilst out on your survey activity *(although we recommend you don't bring anything too expensive or sentimental with you)*

Bicycle Parking

Hedgehog HQ will have space available for you to lock up any bicycles. Please ensure you bring a bike lock with you.

13. Emergency Procedure

A. In the case of an emergency requiring regent's park to close:

- You will be contacted by your supervisor and updated on the situation
- Please follow instructions from your supervisor for next steps

B. In the event you/your group gets lost or separated from your supervisor:

- Please head towards Hedgehog HQ on the Inner Circle to meet up with your supervisor
- If you need directions, please phone Sara Harrison on 07751 817248 or Ledy Leyssen on 07906 634019
- Before you start an activity, please make a note of your supervisors mobile phone number in your field notebook

C. In the case of accident or injury to you/a team member:

- Please phone 999 if serious
- Then phone Sara Harrison on 07751 817248 or Ledy Leyssen on 07906 634019 to update them on the situation

14. Travel

Modes of Transport

- Where possible and safe to do so, we would appreciate people use environmentally friendly modes of transport (e.g. walk, cycling or public transport) to get to The Regent's Park
- If required, parking will be available for the survey period. Please get in touch with Sara Harrison on sharrison@royalparksfoundation.org if you would like to drive and require a parking permit for Regent's Park. She will need the make of car, colour and registration number

Reimbursements

- We are happy to reimburse any reasonable travel expenses incurred during the Hedgehog Survey
- Please ensure you keep any receipts and we will ask you to submit these at the end of the survey period
- If your travel cost will be over £10 please could you let us know before purchasing so we can confirm the cost with you
- We would also ask that any travel which can be covered by a pre-purchased travel card you already own does not get submitted for reimbursement
- We will reimburse you by cheque, this should be sent out to you within 6 weeks of the end of the survey

Late night exit from the regent's park

In May the Regent's Park will close to the public at 9.30pm at night. During our nocturnal surveys (Spotlighting, GPS and Radio Tracking), which will finish after 9.30pm, the exits from the Park will be:

Pedestrian:

- Chester Gate

Car:

- Chester Gate (in)
- Clarence Gate (out)
- Hanover Gate (in/out)

Please see these marked on the A3 map in the back of your pack.

15. Key Contact Details

Hedgehog Project team

Ledy Leyssen: Head of Programmes: Royal Parks Foundation

lleyssen@royalparksfoundation.org

Sara Harrison: Projects Manager: Royal Parks Foundation

sharrison@royalparksfoundation.org

General Royal Parks Foundation Office Number:

0207 036 8040

On call duty manager: Regent's Park: 07969 726083

16. Project Partners

Lead Partners

Independent advisors

- Dr Nigel Reeve
- Emeritus Professor of Ecology John Gurnell

Ancillary Partners

- People's Trust for Endangered Species
- Untyped
- Central Royal Parks Wildlife Group

Acknowledgements

Thanks to Wildlife Aid in Leatherhead for providing us with the hedgehog for volunteer training.

Appendix 4 Recordings Forms

4a Spotlighting

4b Radio tracking

4c Footprint tunnels

4d Camera trapping

Appendix 5 Fieldwork Risk Assessment

Regent's Park Hedgehog Survey Risk Assessment May 214

Action	Hazard	*Who is atrisk?*	Existing Controls	Risk Rating			Additional Controls Required
				L[1]	C[2]	R[3]	
Using equipment and hand tools	Repetitive movements, sharp edges	Hedgehog Project team and volunteers	Demonstration on how to use the equipment and hand tools at the volunteer training session. Gloves to be worn when appropriate. All tools are well maintained.	3	1	3	First Aid kit and first aiders available.
Handling a hedgehog	Sharp spines, bites and germs	Hedgehog Project team and volunteers	All participants and Hedgehog Project team to wear thick gardening gloves when handling a Hedgehog, all gloves to be sprayed with dettox when returned.	3	2	6	First Aid kit and first aiders available.
Nocturnal working	Working in the dark	Hedgehog Project team and volunteers	Volunteers and Hedgehog Project team to each carry a personal torch at all times. Volunteers not to work by themselves and be with another person at all times when working in the Parks. Volunteers have access to the emergency procedure for any problems.	4	2	8	
Working outdoors in the Park	Bending down, repetitive movements causing repetitive strain injuries	Hedgehog Project team and volunteers	At the training workshop and at start of each activity session participants to be reminded to work within their personal capabilities and to take regular breaks. Project supervisors to monitor.	2	2	4	

Working near roads in Regent's Park	Vehicles, bikes, horses and other Park users	Hedgehog Project team and volunteers	Volunteers briefed to be aware of the roads in Regent's Park and their users at the training workshop and at start of each session. Project supervisors to monitor the roads and volunteers throughout the session and be aware of any concerns. Hedgehog Project team and volunteers to all wear hi-viz jackets when on site and carrying out survey activities.	2	2	4	
Working near Regent's Park lake	Proximity of water - falling in	Hedgehog Project team and volunteers	Volunteers and Hedgehog Project team briefed not to go near the Regent's Park Lake at the training workshop and at start of each activity session. Hedgehog Project team to monitor the volunteers and direct any away from the lake if necessary. Survey teams not to go close to the lake particularly during nocturnal activities.	1	3	3	
Working outdoors in the Park	Park fabric causing slips, trips or falls	Hedgehog Project team and volunteers	Volunteers and Hedgehog Project team advised at the training workshop and at start of each activity session not to run on gravel paths or across Park land. Walking routes will be clearly defined and appropriate, stout, footwear to be worn by all.	3	1	3	First Aid kit and first aiders available.

Working outdoors in the Park	Heat or cold related illness e.g. Sunburn, sunstroke, chilblains, hypothermia	Hedgehog Project team and volunteers	Volunteers and Hedgehog Project team advised at training workshop to wear weather-appropriate clothing. Activities to be stopped if volunteers clothing unsuitable for conditions. Spare clothing to be stored at Hedgehog HQ if required.	3	1	3	
Working outdoors in the Park	Coming into contact with the hazardous plants, e.g. Nettle stings, allergic reaction, poisoning if eaten	Hedgehog Project team and volunteers	Volunteers and Hedgehog Project team to be aware of nettles and other stinging plants and advised to avoid them. Volunteers advised not to eat any plants found in the Park. Hand-washing facilities available at Hedgehog HQ.	3	1	3	
Working in the Park	Bird faeces, bacterial infections	Hedgehog Project team and volunteers	Volunteers and Hedgehog Project team advised at the training workshop and at start of each activity session not to put hands in their mouths, hand-washing facilities available. Project supervisors and/or volunteers to carry hand sanitizing gel. Volunteers instructed to wash hands before eating/ at end of session.	3	2	6	
Working in the Park	Presence of dog faeces, Toxocariasis	Hedgehog Project team and volunteers	Volunteers and Hedgehog Project team briefed at the training workshop and at start of each activity session on possible presence of dog faeces and not to touch it.	2	1	2	

Working under and near trees	Falling branches	Hedgehog Project team and volunteers	Regular tree inspections from Park staff. Avoid working under trees in strong wind. Park to close in event of extremely high winds, hedgehog session to be re-scheduled on an alternative day.	1	3	3	
Working near other park users	Violent or aggressive behaviour	Hedgehog Project team and volunteers	Volunteers and Hedgehog Project team to be aware of other Park users. 999 to be called immediately in case of any violent or aggressive behaviour. Volunteers must not work alone during any survey activity.	1	3	3	
Coming into contact with wildlife	Grazes, bites, infection.	Hedgehog Project team and volunteers	Volunteers and Hedgehog Project team advised to not touch wildlife (except Hedgehogs where appropriate) within the Park whilst working on their activity. Particularly waterfowl and dogs.	3	2	6	
Working in park land	Coming into contact with small litter in project site.	Hedgehog Project team and volunteers	Regent's Park litter picked daily. Volunteers and Hedgehog Project team must not touch or pick-up used litter, needles or syringes found during a project. Gardening gloves to be worn where appropriate whilst carrying out activities.	1	3	3	Report any needles or syringes found at the project site immediately to the charity supervisor.

Working outdoors in spring and summer	High pollen count	Hedgehog Project team and volunteers	Volunteers and Hedgehog Project team advised pre-visit if pollen count is forecast to be high so that people with severe allergies may take/bring appropriate medication. In case of severe reaction, phone 999.	2	2	4	First Aid kit and first aiders available.
Working outdoors in spring and summer	Bee, hornet and wasp stings	Hedgehog Project team and volunteers	Remove bee sting as quickly as possible. Watch closely for symptoms. In event of sudden swelling, breathlessness or increased heart rate, ambulance to be called immediately by phoning 999.	1	3	3	
Working near the Wildfowl collection	Intimidation and pecking	Hedgehog Project team and volunteers	Volunteers and Hedgehog Project team to monitor the area throughout the activity time and be aware of any wildfowl encroaching on the space and warn others in their team if approaching.	1	3	3	

Add in site specific detail that may affect the risk rating as stated above (include the date, time and weather conditions).

[1]Likelihood of Occurrence	[2]Likely Consequences	[3]Risk Rating R = L x C
1. Improbable: probability is close to zero	1. Negligible: Trivial injury (requiring minor first aid)	1-5 Tolerable: No additional controls required
2. Remote: Unlikely though conceivable	2. Minor: Minor injury/short term issue	6-10 Low Risk: Probably requiring written guidelines
3. Occasional: Could occur some time	3. Serious: Single severe injury and/or multiple minor injuries	11-15 Medium Risk: Written guidelines required until risk is designed out
4. Probable: Occurs repeatedly/an event to be expected	4. Critical: Single fatality and/or multiple severe injuries	16-20 High Risk: Consider need for activity and additional control methods
5. Frequent: Not surprised if event occurs/will occur several times	5. Catastrophic: Multiple fatalities	21-25 Intolerable Risk: Cease activity

Project Site: Various sites around Regent's Park	
Assessor(s): Sara Harrison	Date: 07.05.2014
Signature(s):	Date for Review: Ongoing during Hedgehog Survey, 19th May – 1st June

Appendix 6 GPS tags and GPS fix location error

I-gotU data loggers have been used to track a range of different species, including seabirds (Soanes *et al.,* 2013), hares (Reid & Harrison, 2010) and squirrels (Stevenson *et al.,* 2013). Advantages of using GPS tags, in comparison with, for example, Radio tracking, include the acquisition of large quantities of data at all times and in all weathers with a much reduced effort in the field by surveyors. However, there are costs to using such technology connected with satellite geometry, satellite obstruction, atmospheric interference, and factors to do with topography, habitat and vegetation (Glasby & Yarnell, 2013, see Frair *et al.*, 2010 for an overview of imprecision and bias in GPS fix locations).The influence of these factors on interpreting the data collected will vary according to the target species and the aims of the study. One way to test the accuracy of the GPS tags is to carry out static field tests in habitat likely to be used by the target animal. Such a test was carried out on 10 GPS tags at Hyde Park between 12:00 and 14:00 on Friday 29th August 2014. The tags, I-gotU travel trackers (A41JF, Maplin, U.K.), had been modified by Mark Ferryman (Forest Research) as described by Stevenson et al. (2013). The 10 tags were numbered 2, 3, 4, 7, 8, 9, 11, 12, 13, 14; the tags were set to record their position every 5 minutes. They were placed on the ground next to each other in 3 'known' locations (coordinates were obtained from Google Earth) for 30-40 minutes at each location. Locations 1 and 2 were in the open, on short grass with no overhead obstructions. Location 3 was on a bank under shrubbery in the grounds of The Lookout in Hyde Park, within 2.5 m of the building and some concrete steps. In the following, the location of where the tags were placed has been termed the 'origin' and each record of its position by a tag, a 'fix'.

The data were downloaded onto a laptop and analysed in Excel. Fix locations were mapped using Google Earth. Accuracy or location error was taken as the distance between each fix and the origin. The mean distance to the origin was calculated for each tag at each location as an overall measure of performance for each tag. Taking into account that the bearings are circular data, the mean bearing for each tag has been calculated. A Raleigh test has been carried out to see if the bearings for each tag differed significantly from random or whether there was a direction bias in each tag.

The findings

Sample sizes were small with between four and seven fixes for each tag at each location (Table 6.1 below). There was a considerable amount of variation in the performance of different tags. For example, the mean distance between fixes and the origin for tag 2 was < 4 m for each location, whereas the comparable figures for tag 14 were17 m, 15 m and 25 m respectively. For most tags the variation in mean distance between the origin and fixes was moderate to low (that is, the Coefficient of Variation was <100%). Tags 12 and 14 produced some odd results in location 3 (the shrubbery) showing a lack of accuracy and precision. An overall measure of accuracy of all the tags and locations combined was 9.6 m with a 95% confidence interval of 3.03 m (N = 162, CV = 102%).The bearings were random for all bar five of the tag-location combinations, despite the mean bearings indicating a tendency towards the north or east (Figure 5).

Accuracy and data filtering

The GPS tags were accurate to within 10 m overall whether in the open or concealed in shrubbery. However, there was some variation in performance between tags and locations. Two tags gave inaccurate and imprecise fixes for the shrubbery location. Glasby and Yarnell (2013)

carried out more extensive tests on GPS Avian bugs from Biotrack Ltd. which they used on hedgehogs. In static tests they had a location error of 6.4 m in open pasture and 15.6 m in woodland. There appeared to be no directional bias in the tags we tested.

Sample sizes were small and further tests for longer duration in different locations in The Regent's Park would be useful, including in the vicinity of iron railings, under different types of vegetation and at different times of the day with different satellite orientations. We do not know how many satellites these tags use in determining their location, although the GPS module MG-S02 used in the tags has the ability to track up to 20 satellites at a time. However, any obstruction may lead to the loss of a signal from one or more satellites. This may result in fix errors or the tags may stop recording altogether (see Frair *et al.,* 2004, 2010). This happened on several occasions in the surveys of hedgehogs at The Regent's Park.

Conclusion

The results indicate an approximate error of ±10 m for hedgehogs when in the open, for example, when foraging at night. However, this error margin could be considerably larger (e.g.15 m to 30 m or more) for hedgehogs under dense vegetation (see Glasby and Yarnell, 2013; Frair *et al.,* 2004, 2010), but further testing is required. Before processing the GPS data collected for each tagged animal, obvious rogue fix points were filtered out taking into account aberrant altitude records and unrealistic speeds of movement. On average, this represents a 14.7% (CV = 33%) loss of records from the 16 GPS tagged animals in May and September. A further filter was applied from a direct inspection of location maps, and fixes that appeared unrealistic, such as 'in water'; this represents a further loss of records averaging 4.9% (CV=99%). A consequence of fix errors is that it was not possible to determine the exact position of nests sites within vegetation during the day using GPS data (see Section 6.6.3).

			Distance to origin							
GPS Tag No.	Test location	No. Fixes	Mean	CoefVar	Median	IQR	Min	Max	Mean bearing from origin	z stat
2	1	7	3.3	51.8	2.2	3.1	2.0	6.1	86	2.09
2	2	5	3.8	109.5	2.8	6.1	1.0	11.1	74	0.38
2	3	6	3.9	93.8	2.6	5.1	1.0	10.8	279	0.40
3	1	6	11.5	37.9	12.1	6.8	4.2	17.0	307	5.52
3	2	4	3.5	67.4	3.2	4.3	1.0	6.7	58	0.72
3	3	5	8.5	17.4	8.9	2.7	6.4	10.3	37	4.88
4	1	5	4.6	61.9	5.1	5.5	1.4	8.1	318	0.52
4	2	5	7.2	47.1	8.0	6.0	2.0	10.8	350	0.17
4	3	7	11.8	48.5	11.2	8.3	4.5	22.0	74	2.84
7	1	6	4.5	76.9	4.2	6.0	1.0	9.2	299	1.04
7	2	5	10.7	91.8	5.4	17.2	3.2	25.7	59	0.21
7	3	5	3.9	73.6	4.1	4.6	0.0	8.1	84	2.46
8	1	6	3.7	36.0	3.4	2.0	2.2	6.0	292	1.39
8	2	4	4.0	41.9	3.8	3.2	2.2	6.1	342	1.67
8	3	7	8.6	44.3	7.3	2.8	5.0	16.6	93	2.66
9	1	5	3.4	29.4	3.2	1.6	2.2	5.0	83	2.62
9	2	5	4.0	112.9	2.2	6.1	1.4	2.2	95	0.02
9	3	6	8.1	56.6	7.6	6.9	2.8	15.8	133	1.31
11	1	5	9.1	31.8	8.1	4.4	7.1	14.0	107	2.25
11	2	4	23.9	85.6	21.1	38.6	2.2	51.0	336	1.92
11	3	6	7.3	52.0	5.9	6.8	3.2	13.0	121	1.65
12	1	6	8.4	53.2	7.3	7.7	2.2	14.4	21	3.71
12	2	5	17.4	12.9	17.5	4.2	14.9	20.6	82	2.38
12	3	6	42.6	21.4	44.2	11.7	26.4	53.7	152	5.95
13	1	6	3.7	40.6	3.9	2.1	1.4	6.0	55	0.08
13	2	5	4.2	46.0	4.0	3.3	2.2	7.3	344	0.20
13	3	6	7.7	69.1	6.6	7.1	2.8	17.7	134	2.94
14	1	5	16.6	18.5	15.3	4.5	14.1	21.9	45	4.65
14	2	4	14.5	32.4	14.7	8.7	8.5	20.0	94	1.56
14	3	5	24.7	30.8	22.8	13.8	14.4	34.0	159	2.22

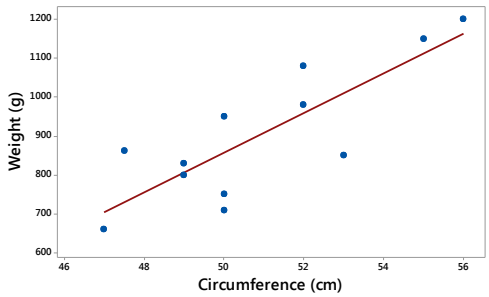
Table 6.1 Mean distance and bearing statistics for the fixes for each tag. Under mean distance to origin, a red mean indicates a value greater than 10, and a red Coefficient of Variation, a value >100%. Under the z statistic column, a red figure indicates the bearings were not random but tended to be clustered about the mean direction.

Appendix 7 Results

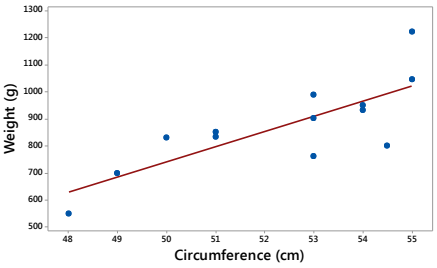
7a Numbers of hedgehog individuals captured in each zone. Animal 32 (male), captured in Zones 2, 4 and 5 in May - 1st caught in Zone 4 and this included in table. Animal 60 (male) captured in Zone 1 in May and Zone 5 in September. Animal 62 (male) captured in Zone 5 in May and Zones 5 and 6 in September - 1st caught in Zone 6 and this included in table.

						Zone				
Month	Sex	Age	1	2	3	4	5	6	7	Total
May	Female	Adult	4	1	1	0	5	1	0	12
		Subadult	1	0	0	0	0	0	0	1
	Male	Adult	7	1	0	1	1	1	0	11
		Subadult	2	0	0	0	0	0	0	2
		?	0	0	0	0	1	0	0	1
	?	Adult	0	0	0	0	1	0	0	1
		Total	14	2	1	1	7	2	0	27
Sept	Female	Adult	4	5	1	1	3	1	0	15
		Juvenile	0	3	0	0	0	0	0	3
		Subadult	3	1	0	0	0	0	0	4
	Male	Adult	4	2	0	0	3	0	0	9
		Juvenile	0	1	0	0	0	0	0	1
		Subadult	3	2	0	0	0	0	1	6
	?	Adult	0	1	0	0	0	0	0	1
		Juvenile	1	0	0	0	0	0	0	1
		Subadult	0	0	0	1	0	0	0	1
		Total	15	15	1	2	6	1	1	41

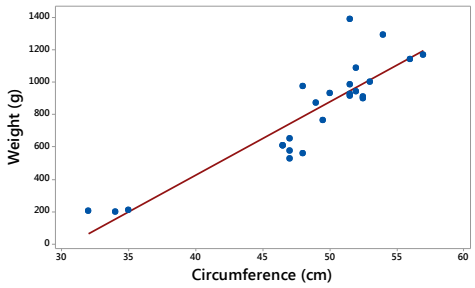
Appendix 7b Scatterplots with trend lines between body weight and circumference of individuals for each month and sex



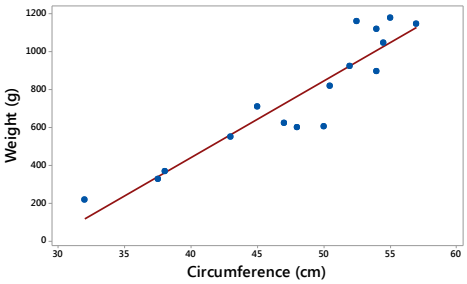
May Female, rs = 0.74, P=0.009



May Male rs=0.74, P=0.004



September Female rs=0.88, p<0.001



September Male rs = 0.93, p<0.001

Appendix 7c Movement and home range statistics for GPS-tracked hedgehogs (a) Night (9pm to 6 am) and (b) Day (6am to 8 pm)

(a) Night

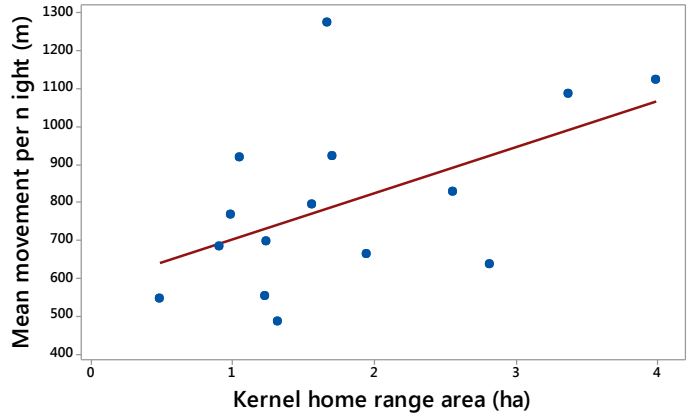
						Distance moved per night (m)			95% Convex polygon range (ha)			95% Kernel range (ha)		
Month	Animal Number	GPS Tag Number	Sex	Weight (g)	No. Nights	Mean	SD	CV (%)	Mean	SD	CV (%)	Mean	SD	CV (%)
May	3	2	M	830	4	919.32	141.625	15	1.31	0.661	50	1.05	0.435	42
May	56	4	F	863	6	662.12	182.268	28	0.94	0.658	70	1.95	1.321	68
May	4	6	M	760	4	697.12	190.689	27	0.65	0.119	18	1.24	0.398	32
May	32	7	M	833	6	1897.13	761.925	40	12.53	7.549	60	16.73	11.689	70
May	86	8	M	1150	5	827.27	359.154	43	2.12	1.121	53	2.56	1.029	40
May	54	9	F	900	2	637.22	306.087	48	2.99	1.571	53	2.81	2.428	86
Sept	8	2	F	1000	7	1274.07	170.417	13	1.67	0.212	13	1.67	0.477	29
Sept	7	3	F	910	7	1124.29	273.128	24	3.25	0.555	17	3.98	0.513	13
Sept	12	4	F	1290	7	1085.04	188.773	17	2.72	0.485	18	3.37	0.458	14
Sept	60	7	M	1180	6	682.53	255.951	38	0.92	1.092	119	0.91	1.166	128
Sept	56	8	F	1140	6	483.90	83.265	17	0.74	0.292	40	1.32	0.627	47
Sept	87	9	F	1085	6	550.83	134.524	24	0.82	0.425	52	1.23	0.817	66
Sept	62	11	F	930	6	768.00	174.212	23	0.66	0.250	38	0.99	0.327	33
Sept	16	12	M	820	12	544.40	239.380	44	0.28	0.206	73	0.48	0.362	75
Sept	33	13	F	870	6	921.95	290.509	32	1.74	0.502	29	1.70	0.502	29
Sept	18	14	F	987	7	794.00	357.361	45	0.80	0.499	62	1.56	1.116	71

(b) Day

						Distance moved per day (m)			95% Convex polygon range (ha)			95% Kernel range (ha)		
Month	Animal Number	GPS Tag Number	Sex	Weight (g)	No. Days	Mean	SD	CV (%)	Mean	SD	CV (%)	Mean	SD	CV (%)
May	3	2	M	830	4	722	309.0	43	1.01	0.510	50	0.69	0.386	56
May	56	4	F	863	6	159	107.0	68	0.14	0.088	61	0.10	0.103	102
May	4	6	M	760	6	638	473.0	74	0.32	0.405	128	0.27	0.418	156
May	32	7	M	833	6	207	155.2	75	0.12	0.066	57	0.07	0.053	74
May	86	8	M	1150	7	270	54.3	20	0.14	0.058	40	0.06	0.022	34
May	54	9	F	900	1	508			0.11			0.07		
Sept	8	2	F	1000	3	198	86.7	44	0.08	0.067	79	0.05	0.029	62
Sept	7	3	F	910	7	272	168.9	62	0.26	0.181	69	0.26	0.226	88
Sept	12	4	F	1290	7	369	162.0	44	0.12	0.031	26	0.06	0.026	45
Sept	60	7	M	1180	6	466	211.6	45	0.13	0.041	32	0.06	0.024	39
Sept	56	8	F	1140	5	135	64.2	48	0.11	0.051	45	0.09	0.085	90
Sept	87	9	F	1085	6	50	58.0	116	0.05	0.025	50	0.02	0.014	74
Sept	62	11	F	930	6	552	120.7	22	0.33	0.147	44	0.20	0.053	26
Sept	16	12	M	820	12	435	159.3	37	0.12	0.074	60	0.08	0.085	110
Sept	33	13	F	870	6	562	148.3	26	0.14	0.027	20	0.07	0.017	25
Sept	18	14	F	987	7	593	229.0	39	0.22	0.146	65	0.18	0.135	73

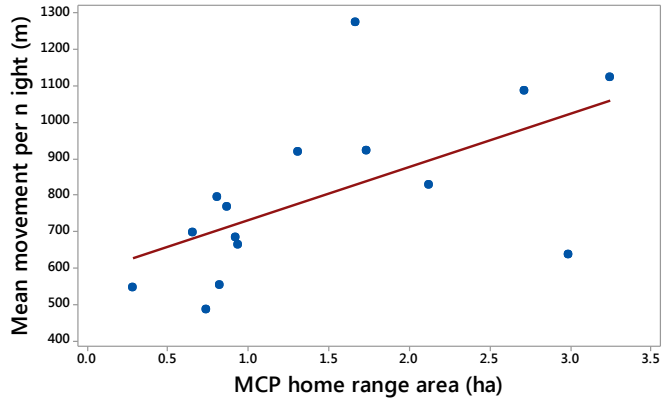
Appendix 7d Pairwise scatterplots with trend lines between mean distance-moved per night, MCP and kernel home range areas

(a) Distance moved and MCP area



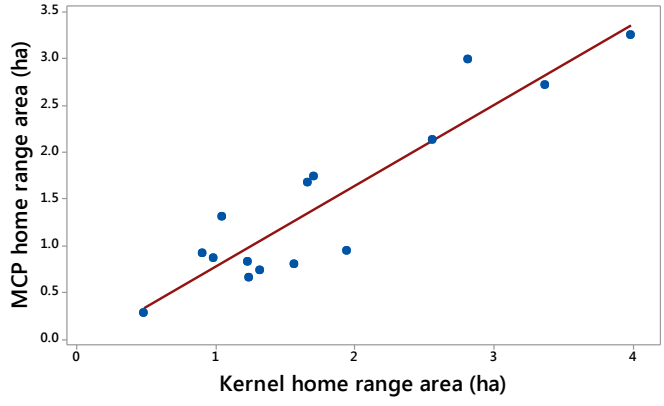
rs=0.47, p = 0.021

(b) Distance moved and kernel area



rs=0.63, p = 0.021

(c) MCP area and kernel area



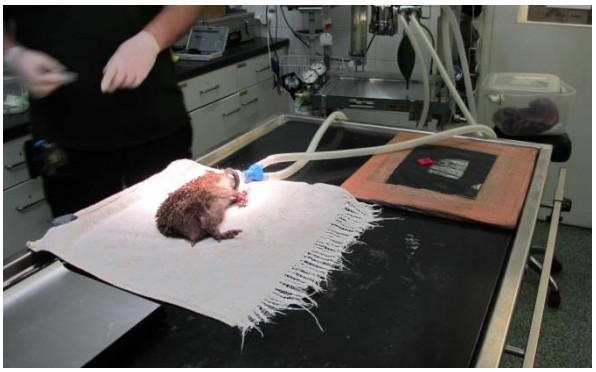
rs=0.79, p = 0.001

Appendix 7e Percentage of habitat locations, each with a 5m circle radius, that fall within different habitat types for each GPS tracked hedgehog

					Habitat										
Animal No.	Sex	Month	No. Locs.	TotalArea(m2)	Planted shrubberies and flower beds	Tall herbs	Improved neutral/acid grassland	Roughland	Semi-improved neutral grassland	Woodland	Hedgerow	Areas not surveyed	Reedbeds and marginals	Open water	Bare artificial habitat	Amenity grassland
3	M	May	231	18143	9.8	0	0.7	0	0	0	1.3	0	0	0	15.1	72.7
56	F	May	164	12881	3.8	18.8	2.2	0	0.9	0	0	21.1	0	20	14.7	18.6
4	M	May	196	15394	11.5	0	2.6	0	0	0	20.4	0	0	0	8.9	56.4
32	M	May	218	17122	3.3	1.5	3.9	0.1	5.3	0	0.4	28	0	1.8	7.7	44.8
86	M	May	113	8875	2.6	0.1	12	1.5	0.3	4.1	0.7	41.8	1.2	1.9	0.7	33
54	F	May	95	7461	0	0	2.5	0	0	0	0.4	28.4	4.1	11	8.5	44.6
8	F	Sept	300	23562	14.5	0	1.3	0	0	0	1.4	0	0	0	10.9	71.8
7	F	Sept	244	19164	2.7	0	0	0	0	0	4.2	4.8	0	0	7.1	81
12	F	Sept	280	21991	0	0	0	0	0	0	2.7	9.3	0	0	4.7	83.1
60	M	Sept	231	18143	0	0	1.7	0	2.9	0	0	52.8	0	1.2	3.5	37.7
56	F	Sept	128	10053	4.5	5.2	1.3	0	0.4	0	0	46.9	0	11	6.6	24.5
87	F	Sept	164	12881	0	0.3	2	0	14.6	0	0	44.1	0	6.3	10.1	22.5
62	F	Sept	248	19478	39.9	0	0	0	0	0	0	2.4	0	0	19.9	37.6
16	M	Sept	435	34165	0	0	68.7	0	0	0	0	18.9	0	0	11	0.1
33	F	Sept	207	16258	0	3.1	14	0	2.8	0	0	32	1.7	2	1.9	42.4
18	F	Sept	238	18692	0	0	63	5.2	0	0	0	3.4	0	1.9	24.2	0.4

Appendix 8 Veterinary reports from the ZSL team

Hedgehog # 002
Date found: 2145 on 23/05/14
Found by: Nigel Reeve
Location: TQ 28639 82525
Assessing vet: Nic Masters and RVN Matthew Rendle
Outcome: Released

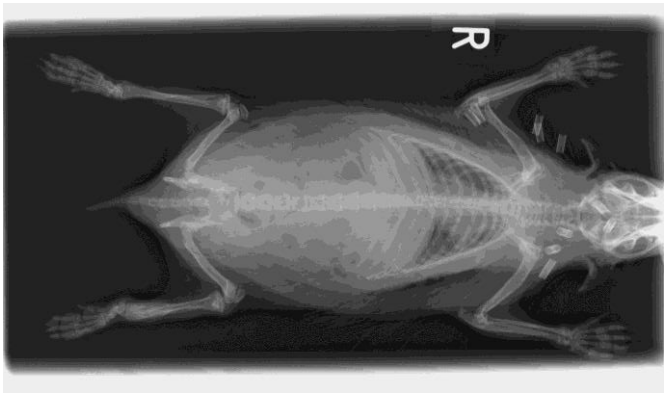


Recorded as a female weighing 690g and with 'maggots in the ear'.

Moved to vet hospital and left overnight in a pet carrier with towel, water and canine A/D food. Ate and drank and defecated overnight.

Induced anaesthesia with isoflurane in oxygen. Right ear canal was filled with more than 10 fly larvae which were removed with forceps. Ear canal was examined and found to be very thickened and inflamed but intact. Flushed with sterile saline and instilled Canaural ear drops. Right hind leg was slightly misshapen and found at radiography to have a healed fracture of the tibia. It is likely that this restricts this animal's ability to groom around its right ear, but not to forage. General skin condition was a little poor with slightly sparse spines and some crusting. A single partially engorged tick was found on the right flank. Gave 0.15mg ivermectin topically (Zeno 50) on back of neck. Actual body weight = 661g and BCS was thin (2/5). Took faeces from overnight box for Baermann flotation (lungworm) and routine parasitology and bacteriology. Assessed as fit for release although ear problem may recur over time. To be released at the same location as found, on the night of 24.5.14.

Nigel Reeve re-released hedgehog number 002 at dusk on 24.05.14 and it looked well as it scuttled away into the undergrowth



Hedgehog # 999:

Date found: 23/05/14
Found by: Nigel Reeve
Location: Found at the SE corner of the zoo, but within the park adjacent to Ready Money Fountain
Assessing vet: Nic Masters / Tim Hopkins
Outcome: Euthanased

Not recorded fully as surveyors spotted badly damaged leg immediately. Subsequently given number 999. Moved to vet hospital and left overnight in a pet carrier with towel, water and canine A/D food. Ate and drank and defecated overnight.

Induced anaesthesia with isoflurane in oxygen. Female weighing 680g. BCS was very thin (1.5/5). Right hind leg was missing the foot and tarsus, terminating in a non-healing stump. Higher, at the level of mid-tibia, was a complete and compound fracture that was infected.

Euthanased on welfare grounds. Took faeces from overnight box for Baermann flotation (lungworm) and routine parasitology and bacteriology.

Carcass examined by Institute of Zoology staff under the auspices of the Garden Wildlife Health project:

This adult male hedgehog was found within Regent's park using a radio tracking device. There was an open comminuted fracture of the right tibia and fibula that would have significantly hindered its ability to behave normally and evade predation. There was no evidence of infectious disease on gross post-mortem examination, microbiological or parasitological testing. While histological examination may prove useful in this case, it seems most likely that this hog would have died due to secondary infection associated with its hind leg injury.

Hedgehog #54 (radiotagged)

Date found: 30/05/14
Found by: Sara Harrison
Location: Zone 5
Assessing vet: Tim Hopkins
Vet report ref: OBS202811450
Outcome: Euthanased

This subadult male hedgehog was in normal body condition and had been eating before death. It was quite pale and had a very blond coat.

Both external auditory meatus were struck with fly larvae and there was a marked infection of the right auditory canal.

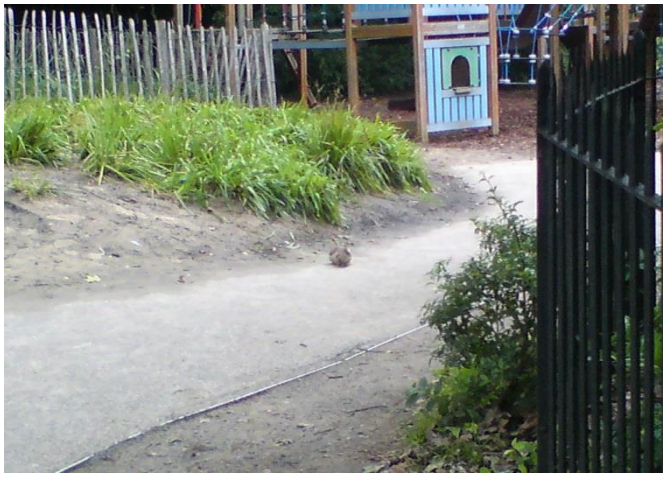
There was evidence of old healed skeletal injuries such as broken pelvic arch and broken right tibia. The right zygomatic arch was incomplete though it was not obvious if this was a congenital or acquired deformity.

Purulent material could be expressed from the fascia near the right bulla, temporomandibular joint, periorbital space and the caudal most upper molar (absent). A marked cellulitis, fascitis secondary to trauma seems most likely.

Microbial testing failed to reveal any significant pathogens. Numerous capillaria sp. eggs were seen on a wet mount of the small intestine contents.

Numerous adult *Ixodes hexagonus* ticks were removed from the skin.

This hedgehog probably would have died from an infection secondary to trauma. There was evidence that it had survived traumatic injuries in the past.



Hedgehog – not allocated a survey number as in such a poor state

Date found: 29/05/2014
Found by: Ledy Leyssen and Marion Buggins
Location: Zone 5 - North end of Regent's Park – between wildlife centre and sports pitches
Assessing vet: Lydia Franklinos
Vet report ref: OBS202583368
Outcome: Died in transit to the vet

This adult female hedgehog was in normal body condition and had been eating before its death. Noted to be quite blond in colour

There was a congested area on the left lung with an associated encysted area. Evidence of pulmonary infection with parasites was found testing for microbial agents failed to identify significant organisms.

The stomach appeared to have a mottled surface but all other internal organs appeared normal apart. There was no evidence of intestinal infection with parasites.

The bladder was very large and full of urine in which blood was detected. Further examination of the bladder and kidneys is required to assess if a urinary tract infection occurred in this animal.

Histopathological examination of the stomach, bladder and kidneys will be performed to further investigate the abnormalities in these organs.

Haemorrhage (bleeding) was apparent in the tissues around the neck and muscle damage was also observed here. This is most likely due to trauma but it is difficult to associate this trauma with the cause of death.

Testing for microbial agents in various tissues failed to identify significant organisms.

The cause of death in this case remains undetermined but we will be performing histopathological examination of various organs to try to elucidate possible causes.

Hedgehog #4 (radiotagged)

Date found: the evening of 30/05/14
Found by: Nigel Reeve
Location: Zone 1
Assessing vet: Tim Hopkins
Vet report ref: OBS202404487
Outcome: Found dead

The adult male hedgehog was found dead. It had a radio and a gps tracker attached to it hence the cut spines. I noticed its back right leg was damaged so I have taken a radiograph and it is indeed broken in several places.

This adult male hedgehog was found within Regent's park using a radio tracking device. There was an open comminuted fracture of the right tibia and fibula that would have significantly hindered its ability to behave normally and evade predation.

There was no evidence of infectious disease on gross post-mortem examination, microbiological or parasitological testing.

While histological examination may prove useful in this case, it seems most likely that this hog died due to its hind leg injury. Given the body condition and absence of other wounds, a secondary infection, rather than predation or starvation, seems the most likely cause of death.

Hedgehog #61

Date found: 24/05/2014
Found by: John Gurnell
Location: Zone 1
Assessing vet: Lydia Franklinos
Vet report ref: OBS201963054
Outcome: Euthanased

This adult female hedgehog was in normal body condition and had been eating before its death.

All internal organs appeared normal apart from the lungs that were congested and had evidence of parasitism with lungworm *Capillaria* sp. There was no evidence of intestinal infection with parasites.

There was an old open fracture to the right hindlimb with associated scar tissue and infection. A swab of the wound was taken and the bacteria *Pasteurella multocida* was isolated. This bacterium occurs commonly as part of the normal respiratory tract flora in many mammals including hedgehogs in which is it rarely reported.

Cats are the most common mammal from which the bacterium is reported. Therefore this injury may have occurred to due predation by a cat or other mammalian predator, otherwise the bacterium may have occurred in the wound due to the hedgehog licking the site.

There were no lesions seen in other body systems that were compatible with infectious disease, and testing for microbial agents failed to identify significant organisms.

This hedgehog was euthanased due to a chronic fracture in its right hindlimb which may have occurred due to trauma by predation, traffic collision or escape injury.

Appendix 9 Habitat management recommendations for hedgehog conservation in The Regent's Park

Retain and enhance habitat suitable for nesting:

Hedgehogs require safe undisturbed nest sites all year. Unlike birds, there is no season during which hedgehogs do not use their nests. Nests provide a daily refuge during the summer and they hibernate in nests during the winter. In the summer, nests can sometimes be makeshift and/or constructed of grass and other flimsy materials but the majority will be well-made using layers of leaves from broadleaved trees. The illustration below (from Reeve 1994) shows the typical construction of a hibernation nest (hibernaculum), but summer nests may be equally as well constructed. Normally the nest is tightly packed under restraining vegetation such as brambles, fallen branches and low shrubs, but may also be found in many other places where there is adequate cover and support including grass tussocks, disused rabbit burrows, tucked against a fence, or under the raised floor of a shed or other outbuilding; anywhere that offers support and protection.

Figure 9.1 Hedgehog hibernation nest.
Drawing by Ruth Lindsey
Source: Reeve (1994)

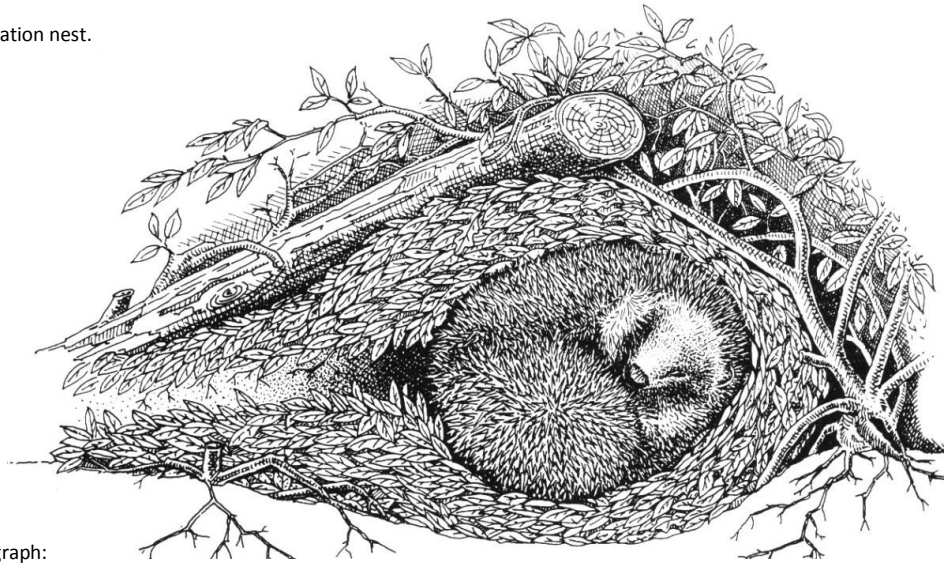


Figure 9.2 Hedgehog nest. Photograph:

Nests are usually hard to find by searching. The photograph shows a typical nest among a patch of brambles which have been parted to expose the nest (marked with a coin). Often they resemble no more than a slight mound in the leaf litter.

A key element in managing a site for hedgehogs is to ensure that the maintenance of nesting sites is specifically incorporated into the management regime. Fallen leaves should be retained and structures that may support nests (such as informal log piles, brash or dead hedges) should be maintained on site as well as areas of suitable undergrowth, brambles and tussocky grass. For habitat management, periodic cutting is usually required. If so, then initial cut with strimmer or brush-cutter should be at an absolute minimum height of 15cm (6 inches) to protect the majority of nests. The area should then be searched for nests and no further cutting should take place around any found. No area of undergrowth should be cleared entirely but at least one

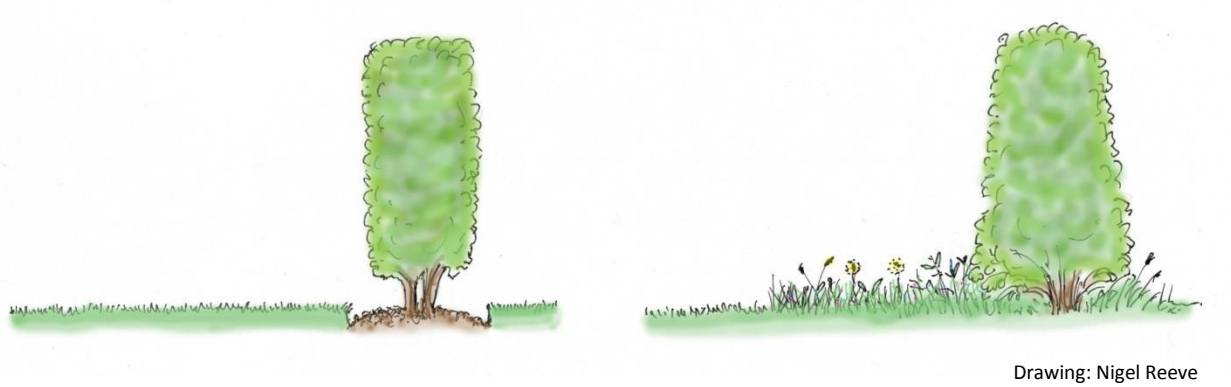
third retained uncut to maintain a continuity of wildlife habitat. This strategy will not only protect hedgehogs but also other wildlife in the undergrowth such as mice, voles, newts, frogs and toads. The bases of hedges should be maintained in such a way as to provide nesting opportunities for hedgehogs (see below).

Provide suitable foraging habitat:

Hedgehogs principally are predators of a wide range of ground invertebrates but their diet may also include larger prey items, carrion and food scraps. Maintaining a good natural food supply for hedgehogs is best achieved by facilitating a biodiverse flora and soil, which will in turn provide the worms, beetles, caterpillars, slugs and snails and so on that hedgehogs prey upon. As well being desirable for wildlife conservation generally, the availability of a diverse invertebrate community throughout the year is essential for hedgehogs as also for many other ground invertebrate feeders including birds such as thrushes, blackbirds and robins.

Hedgehogs preferentially forage within 5 metres of cover (e.g. woodland edge, hedgerow or shrubbery) but can move quickly and efficiently in shorter grass. Hence mown areas can be attractive foraging areas for hedgehogs as long as the grassland is not so intensively managed as to reduce prey availability. In our study, this was evidenced by the fact that although amenity grassland was favoured by foraging hedgehogs, no hedgehogs at all were found in the intensively managed sports pitch areas which are also far from cover. A frequently-mown ryegrass (*Lolium perenne*) monoculture supports few species and wherever possible, general amenity grassland and informal sports areas should be managed for higher floral and invertebrate diversity.

The figure below illustrates intensively managed grassland on the left where the grass is tightly mown and the base of the hedge is kept free of vegetation and leaf litter. This offers little for hedgehogs, but on the right, the dense base of the hedge provides a potential nest site, and the headland strip of longer grassland (about 2 metres wide) provides a diverse native-species floral mix with less compacted soil which would support a greater diversity of invertebrate prey.



Drawing: Nigel Reeve

The current study gathered insufficient evidence about foraging within flower beds and the positive or negative effects of mulching with composted leaf material. Nevertheless, we suggest that hedgehogs would benefit where leaf-fall is allowed to accumulate and decompose naturally within shrubberies and flower beds. Fallen leaves are typically an essential component of hedgehog nests, and hedgehogs prey on the macroinvertebrate community within leaf litter.

Maintain and improve continuity of habitat:

In The Regent's Park the fencing mainly consists of vertical iron railings spaced with a gap wide enough for hedgehogs to pass through at ground level. Evidence from the GPS tracking of hedgehogs in this study suggests that the majority of boundaries are permeable to hedgehogs, allowing them to move freely throughout the park in search of food, nest sites and mates. However, any project that may involve the renewal or augmentation of fencing, for example using chain link fencing, should take care to ensure that this permeability remains and that gaps of around 13cm (5 inches) width are maintained at ground level.

Hedgehogs benefit where there is a matrix of foraging and nesting habitats close together. Although they may on occasion cross large open spaces, hedgehogs normally remain within a few metres of cover. Therefore, if suitable areas of hedgehog habitat are connected by hedge lines and areas of longer grass this increases the ease with which they will be able to move freely throughout the park. Thus a conscious plan to defragment suitable habitats in the park will benefit hedgehogs as well as other wildlife such as the invertebrates that they feed upon.

Continuity of habitat in time should also be considered when cutting or managing areas of species-rich grassland, undergrowth, hedgerows and so on. Where the management may temporarily reduce foraging or nesting habitat, care should be taken to conserve a sufficient resource. Retaining at least one third of any species-rich area will allow longer-lived and more specialised invertebrates to persist in the area as well as for example small mammals and amphibians. It is helpful to have a management plan in which areas are dealt with in rotation, such as a three year cycle in which one third of the habitat is cut back each year. The optimum period of such a rotation will depend on the growth cycle of the vegetation in question.

Avoid hazards to create a safe environment:

Strimmers and brush cutters are designed to cut back rank vegetation in the very places hedgehogs nest, and may kill or cause causing serious wounds to sleeping or hibernating animals. Therefore always cut initially above 15cm (6 inches) and thoroughly inspect for nests before cutting at ground level if necessary.

Hedgehogs may nest under temporary heaps of green waste and heaps of material for burning. Where such material has been left overnight, always proceed carefully when using forks and machinery, and check through to the base of the pile carefully before burning.

Hedgehogs commonly become trapped in formal lakes or ponds and all sunken areas with steep sides. Barriers (at ground level) should be erected around temporary holes, or they should be covered. More permanent structures such as sunken patios or formal pond and lake edges should always have ramps to help animals climb out.

Netting is also dangerous unless firmly staked down and kept taut to avoid hedgehogs and other animals (especially birds) becoming entangled. Netting should always be checked daily.

Pest control of rats or other species may involve the use of poison bait or traps. Care should be taken to ensure that hedgehogs are excluded from such potential hazards.

If a nest is accidentally disturbed during work on the site, bvand if the hedgehog is uninjured, withdraw and allow the animal to relocate itself before continuing work the next day. If a nest of

youngsters is found, re-cover the babies at once with the original nest material – avoid handling the animals as your scent may cause their rejection by the mother. Do not assume that they are abandoned if their mother is not there or runs off. Avoid further disturbance and allow the mother to either continue to nest in that location or to relocate her nest and transfer her young. Only if the mother fails to attend the young before the following night, or the youngsters begin to crawl from the nest should rescue be considered. Seek advice from an experienced person.

Monitoring hedgehog populations:

Occasional sightings and the presence of hedgehog signs, such as their distinctive droppings, can be useful to indicate the continued presence of hedgehogs on a site, but monitoring of the population reliably to detect population change can only be achieved by systematic and repeated surveys. This may involve the use of footprint tunnels but from the findings of this study we recommend the use of standardised searches using spotlighting.

As the hedgehog population has been found to be low, it is recommended that spotlighting surveys, using standardised routes to cover the whole area of the park, are repeated annually in the first half of September. This timing should detect the presence of mature animals, plus this year's young, and so should give some indication of breeding having taken place. Once a population trend is established the period between surveys can be re-evaluated.

Population management:

Our study suggests a total population in the region of 50 individuals within The Regent's Park. Without longer-term monitoring and other information we have no information yet as to the future status of this small population. The primary approach to population management should be to optimise conditions for this species by appropriate site management to allow the population to grow.

The isolation of the population within the Park and the relatively small numbers of individuals may leave it vulnerable to extinction from natural fluctuations in the population size resulting from things like poor weather, increased predation, temporary drops in food supply from drought. Genetic isolation can also sometimes play a part in reducing the viability of animal populations.

A common suggestion made is that hedgehogs could be brought in from another site to bolster the population. It should be emphasised that no translocations should take place unless recommended on scientific evidence and carried out as part of a proper study licensed by Natural England under the terms of Wildlife and Countryside Act, 1981. Taking hedgehogs from the wild by an unlicensed person is a criminal offence, and whether or not the hedgehogs have been directly sourced from the wild or come from a wildlife rescue organisation, releases should have due regard to IUCN and UFAW guidelines and must not contravene the terms of the Abandonment of Animals Act, 1960.

Appendix 10

10a Press Release sent out in October 2014

THE ROYAL PARKS FOUNDATION

PRESS RELEASE

Embargoed until 00:01 27 October 2014

Unearthing the secret lives of hedgehogs in London's Regent's Park

New survey reveals hedgehogs are athletes says
Royal Parks Foundation team leading research in London's Regent's Park

One of the UK's biggest inner-city hedgehog surveys, now underway in the capital's Royal Parks, has revealed the nocturnal lives of one of Britain's best-loved small mammals, the British hedgehog. With hedgehog numbers declining nationwide, Regent's Park is the only central London Royal Park to have retained a resident hedgehog population.

A total of 45 individual hedgehogs were found during the survey indicating a significant population in a park of this size – 1.6 km^2 (160ha). Some of the animals were seen to cover an area of up to 30,000 m^2 (3ha) in a single night and their preferred park habitat appeared to be rough grassland and shrubby areas.

Far from ambling slowly, hedgehogs are actually quite athletic travelling up to 1.5 km, nearly one mile, per night according to the survey's initial findings. In the scale of a hedgehog's body size and average leg length (10 cm), that's the human equivalent of a man with a 32-inch inside leg walking 12 km every day and more than 80 km a week. Alternatively, 1.5 km is three stops on the Underground between Regent's Park and The Angel, Islington!

More than 60 volunteers aged from 20 to 70 years old, known as 'Hedgehog Heroes' helped undertake this unique hedgehog survey in Regent's Park. Led by eminent wildlife biologists Dr Nigel Reeve and Professor John Gurnell, the research has been made possible by a unique partnership between The Royal Parks Foundation, The Royal Parks and The Zoological Society of London (ZSL) – with thanks to a generous private gift to the Royal Parks Foundation.

Sara Lom, CEO of the Royal Parks Foundation, the charity for London's eight Royal Parks, said: "This survey brings together expert scientists, wildlife conservation organisations and local volunteers. One of the important aims of the project is to educate the local community and park users about the resident hedgehog population so that they will help protect and support them in the future."

Julia Clark, The Royal Park's Head of Ecology said: "For Regent's Park to be the only central London Park with a viable population of hedgehogs is a significant find. We know that urban landscapes are increasingly important to hedgehogs. The results from this survey such as habitat preferences will enable us to create more hedgehog friendly habitats across London's

Royal Parks. Everyone can help reverse the trend of this declining species by planting native hedges, leaving 'wild' areas in gardens or simply by making small holes in walls or fences to connect gardens."

Kat Ellis, aged 25, lives in Holborn and says the project was the first time she'd seen a hedgehog in the city. Kat said: "Being involved in this study was so eye-opening. I never realised that these amazing little mammals literally live on my doorstep. The highlight was definitely handling a real-life hedgehog (something I never imagined I would do!) I now see the parks through different eyes and will do all I can to help support them."

'Hedgehog Heroes' learnt to spotlight the prickly animals with specialised LED torches and hi-tech tracking equipment to monitor and observe hedgehogs during the night without intrusion. Some of the hedgehogs had bespoke lightweight radios and miniature GPS transmitters attached for one week to track their movements around the park. The team also positioned footprint tunnels in strategic locations with Frankfurters as bait to tempt in the hedgehogs. A dozen night cameras then captured their 'sniffing' and foraging behaviour.

Dr Nigel Reeve, one of the UK's leading hedgehog experts has been working with the team on how best to monitor the hedgehogs. He said: "This is a fantastic opportunity to investigate this population for which we had no information at all. For the first time, we can obtain some real data which allows us to understand how hedgehogs use the park".

Professor John Gurnell from Queen Mary, University of London will present final research findings from the survey in Spring 2015. One of the key actions will be to develop habitat recommendations to help conserve the hedgehog population in Regent's Park and inform other parks and urban open spaces around the country.

This partnership research project also includes wider partners Central Royal Parks Wildlife Group, Peoples' Trust for Endangered Species and Untyped, and has been made possible thanks to a private gift given to the Royal Parks Foundation.

For more information about the project or to support wildlife in the Parks, visit www.SupportTheRoyalParks.org

For press enquiries or photographs please contact Faith Mall at the Royal Parks Foundation on 0207 036 8043 or at fmall@royalparksfoundation.org.uk

NOTES TO EDITORS

The Royal Parks Foundation

The Royal Parks Foundation is the charity that helps support the magic of London's eight amazing Royal Parks. The charity reaches out to make the Parks part of more people's lives and raises funds for a wide variety of heritage, education, wellbeing and nature conservation programmes (registered charity 1097545). For information on the Foundation, visit www.SupportTheRoyalParks.org

The Royal Parks Foundation delivers a wide ranging and accessible outdoor education programme at the **Isis Education Centre** in Hyde Park. The schools programme for primary and secondary schools is linked to the National Curriculum, and there is a year-round programme of informal activities for individuals and groups to join, from guided walks to hands-on sessions.

The Royal Parks: Almost 40 million Londoners and tourists visit the eight Royal Parks each year. The 5,000 acres of historic parkland provide unparalleled opportunities for enjoyment, exploration and healthy living in the heart of London.

The Royal Parks are: Bushy Park, The Green Park, Greenwich Park, Hyde Park, Kensington Gardens, The Regent's Park and Primrose Hill, Richmond Park and St James's Park. The Royal Parks also manages Victoria Tower Gardens, Brompton Cemetery, Grosvenor Square Gardens and the gardens of 10, 11 and 12 Downing Street.

For further information please visit: www.royalparks.org.uk.

ZSL

Founded in 1826, the Zoological Society of London (ZSL) is an international scientific, conservation and educational charity whose mission is to promote and achieve the worldwide conservation of animals and their habitats. Our mission is realised through our ground-breaking science, our active conservation projects in more than 50 countries and our two Zoos, ZSL London Zoo and ZSL Whipsnade Zoo. For more information visit www.zsl.org

Ancillary Partners

Peoples' Trust for Endangered Species, PTES - www.ptes.org

PTES is a UK conservation charity created in 1977 to ensure a future for endangered species throughout the world. Working to protect some of our most threatened wildlife species and habitats, it provides practical conservation support through research, grant-aid and educational programmes, including wildlife surveys, publications and public events.

Central Royal Parks Wildlife Group

The Central Royal Parks Wildlife Group brings together amateur and professional naturalists and ecologists who share an interest in the amazing range of wildlife which survives within the Central Royal Parks, and promotes wildlife-friendly management alongside other priorities for the parks.

Untyped

All data for this project is collected and hosted on *Cartographer* (http://cartographer.io), a cloud-hosted service for crowd-sourcing environmental data. Cartographer allows environmental groups to collect data from volunteers and display it using custom maps and charts. The software is developed by *Untyped* (http://untyped.com), who kindly provided us with custom setup and support.

Appendix 10b Hedgehog coverage in The Times, in print and online on 27 October 2014

ROSS PARRY / SWNS GROUP

Hedgehogs found to roam far and wide

Hedgehogs can shrug off their reputation as ponderous, slow-moving creatures — according to research they walk about a mile every night (Kaya Burgess writes).

Wildlife biologists tracked 45 of them in Regent's Park, London, to examine their movements, in an effort to learn more about the creatures and arrest their decline in number. They were found to range across seven acres a night, equivalent to a human walking more than seven miles a day.

Led by Nigel Reeve and John Gurnell, biologists, and with support from the Zoological Society of London, 60 volunteers attached GPS systems to the hedgehogs and tracked them for a week. They found that they preferred rough grassland and shrub-filled areas for foraging.

Julia Clark, the head of ecology for the Royal Parks, said: "For Regent's Park to be the only central London park with a viable population of hedgehogs is a significant find. We know that urban landscapes are increasingly important to hedgehogs.

"The results from this survey, such as habitat preferences, will enable us to create more hedgehog-friendly habitats across London's royal parks. Everyone can help reverse the trend of this declining species by planting native hedges, leaving 'wild' areas in gardens or simply by making small holes in walls or fences to connect gardens."

Source URL: http://www.thetimes.co.uk/tto/environment/wildlife/article4248562.ece

THE TIMES

Wildlife

Hedgehogs found to roam far and wide

Kaya Burgess
27 Oct 2014 14:33:46

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