



Surveys of Hedgehogs in The Regent's Park, London 2014-2023

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**Working in
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Summary

The European hedgehog, *Erinaceus europaeus*, is a well-known and much-loved mammal, but over the last 30 years or more there is good evidence that its population is in marked decline in Britain. In the early 1970s, hedgehogs were found in all of London's central Royal Parks. However, they have since vanished from all central London locations except The Regent's Park. The Regent's Park, one of London's eight Royal Parks, spans 166 hectares, with The Royal Parks directly managing about 124 hectares. The reasons for the decline and local extinctions of hedgehogs in central London are unclear, but habitat fragmentation, site isolation within the urban landscape, and issues related to habitat management are likely significant contributors. A 10-year programme of surveys and other studies on the hedgehogs in The Regent's Park began in 2014 and continued until 2023. The main aims at the outset were to understand the size of the hedgehog population, where they lived and the habitats they used within the Park, and how these may change from year to year. An additional aim was to engage volunteers, the local community and other stakeholders in the project. The findings from the studies will be used to develop habitat management recommendations and conservation actions that may be required.

To monitor the number and distribution of hedgehogs in The Regent's Park, spring and autumn night-time spotlight surveys were conducted by volunteers every year between 2014 and 2023. The background and methodology of these and other related studies are detailed in previous reports (see References). Primrose Hill, lying to the north of the main Park was surveyed in 2015, but no hedgehogs were found; it was excluded from subsequent surveys and is not included here. In this report we update the data from the 2021 report (see references) with the findings from 2022 and 2023 and provide an overview of the survey data collected over the whole 10 years of the project. Throughout the studies, ZSL Veterinary Services provided veterinary support, and the Garden Wildlife Health Project performed post-mortem examinations on any dead hedgehogs found in the Park.

Each survey involved up to 120 volunteers following standard methods. The Park was divided into six zones, with five volunteers assigned to systematically survey each zone using torches and thermal imaging cameras. The surveys were conducted in two shifts, from 21:00-00:00 and 00:30-04:00, on two consecutive Friday nights. A seventh zone, covering the grounds of London Zoo, was surveyed by Zoo personnel. The survey program was interrupted in 2020 when the spring survey was cancelled due to Covid-19 lockdown restrictions. However, the autumn survey was carried out with modifications to the standard protocol, resulting in a slightly different and reduced survey effort, so the data should be interpreted cautiously.

Each hedgehog captured was uniquely marked with plastic sleeves attached to the spines on the back of the hedgehog. They were sexed, weighed, and examined for ectoparasites and injuries. Sick or injured hedgehogs were examined by veterinarians and either released back into the Park after treatment or euthanised if the injuries were severe. An analysis of hedgehogs known to be alive from previous and subsequent captures but missed in a particular survey suggests that the survey method has been effective at sampling the hedgehog population.

From 2014 to 2019, the hedgehog population in the Park was small, averaging 29 individuals known to be alive at the time of each survey. However, numbers fluctuated from year to year and season to season, with a low in spring 2016 and highs in autumns of 2014 and 2017. Generally, autumn numbers were higher than spring numbers due to the recruitment of young from summer/autumn breeding. From autumn 2020 until the end of the study in autumn 2023 there was a steady decline

in numbers reaching a low of just six individuals found in spring 2023, with a small recovery to 10 individuals found in the autumn of that year, leaving the population in a precarious position.

On average, adult female hedgehogs were slightly heavier than males, and both sexes were heavier in autumn than in spring. With the exception of injured or sick hedgehogs, captured hedgehogs appeared to be in good body condition. Breeding success varied yearly, with particularly low success in 2015 (four juveniles captured), leading to a low spring population in the following year. Breeding success was also low in 2021 (four juveniles) and towards the end of the study when four, two and three juveniles were captured in 2021, 2022 and 2023 respectively. In other years, recruitment was moderate (6-15 juveniles) and generally unremarkable, except for 2017, when it was relatively high (21 juveniles).

Generally, the adult sex ratio was skewed toward females, especially when numbers were low suggesting a difference in persistence¹ between the sexes. Persistence over summer in both sexes (on average males 51%, females 64%) and over winter in adult males (64%) were similar whereas adult females overwinter was slightly higher (73%). Overwinter persistence in juveniles was lower and again slightly higher in female juveniles (males 36%, females 46%). Otherwise, persistence varied between seasons and years without a clear pattern. When data on juveniles captured during the autumn were pooled across all years, it was found that 64% of males and 58% of females disappeared within one year, and 83% of males and 80% of females within two years. Less than three per cent persisted for three years and none persisted for four years. These figures show that the persistence or survivorship of hedgehogs in The Regent's Park is poor and appears to be much lower than reported in other studies, where some individuals may live for six or more years. During the study Zoo or Park staff, members of the public, and volunteers found 88 hedgehogs that were either dead or so severely injured that they had to be euthanised by veterinarians. Fifty-two per cent of dead hedgehogs were tagged, about 27% of all the animals marked during the study.

More of the dead hedgehogs were found in summer, less in spring and fewest in autumn. Where the cause of death was identified, 43% of adults and 95% of juveniles are believed to have been killed or severely injured by predators, most likely foxes, although dogs cannot be ruled out. The main injuries in these cases were broken or severely damaged hind legs. For such a small population, these numbers are high, especially considering that many deaths likely go undetected. Other causes of death included road kills, lung infections, ear infections, and drowning. Additionally, deaths of young animals in the nest, before they begin foraging independently, cannot be accounted for.

The distribution of hedgehog captures within the Park has been patchy and has shifted over the 10 years of the study. In 2014 and spring 2015, there were many captures in the west, south, and northeast, including the Zoo Car Park. Captures were low in other areas, including around the sports pitches in the mid-northern part of the Park. This situation changed quickly over the summer of 2015, with hedgehog captures dropping dramatically in the south and west, areas that have not recovered, with captures between 2016 and 2021 remaining few and sporadic. Between 2016 and 2020, there was a modest increase in captures around the sports fields, while the northeast continued to be a stronghold. However, captures in the Zoo Car Park declined over this period, with no hedgehogs found there in the last four years of the study. In 2017, a part of the Zoo Car Park was

¹ The term persistence rather than survival has been used because it is not known whether marked hedgehogs that disappeared had died or simply were not captured.

requisitioned by Thames Water to replace a major water main, and then by HS2 as a lorry holding area during the construction of the high-speed rail line out of Euston. Although these works may have affected animals in the area, they are unlikely to be solely responsible for the loss of hedgehogs.

The major shift in distribution in 2015 coincided with a major population decline indicating the link between distribution and abundance. From 2020 onwards the declining population has centred on the north-east quadrant of the Park. The reasons for these changes are not fully understood. Based on the available area and habitat, it is unclear why the Park does not support three or four times the number of hedgehogs it had between 2014 and 2019. It is also unclear why hedgehogs do not persist or survive for very long or why females fare slightly better than males. From an analysis of dead hedgehogs, predation by foxes (possibly dogs) appears to be an important factor affecting persistence in adults and especially juveniles, thus influencing recruitment. Other factors such as habitat management, disturbance, weather, food availability, inbreeding and rodenticide use at the Zoo and food outlets may have played some part, but convincing evidence is lacking (see previous reports). From the start of the study, the small size of the population has made it vulnerable to demographic as well as environmental stochasticity and it seems that a combination of poor persistence and recruitment, perhaps together with other factors, are preventing population growth and limiting distribution in this population.

The hedgehog population in The Regent's Park is isolated, fluctuated at a low level between 2014 and 2019 and declined to very low numbers between 2020 and 2023, the end of the 10-year study. The population is vulnerable to extinction at any time. At the time of writing in 2024, The Royal Parks, ZSL and other stakeholders are carrying out a systematic review and risk analysis of possible factors limiting the population and are considering conservation measures including further habitat management and an introduction programme to reinforce the population.

Contents

		Page
	Summary	2
1	Background	6
2	Aims of the surveys	6
3	Project partners	6
4	Survey organisation	7
	4.1 Survey dates 2021	7
	4.2 Survey zones	7
	4.3 Surveyors	8
	4.4 Veterinary support	8
5	Survey methods	9
	5.1 Spotlighting, using torches and thermal imaging cameras (TIC)	9
	5.2 Data handling	9
6	Results	10
	6.1 Population dynamics	10
	6.1.1 Numbers of individuals known to be alive at the time of each survey	10
	6.1.2 Recruitment	11
	6.1.3 Seasonal persistence	12
	6.1.4 Persistence curves	13
	6.1.5 Deaths	14
	6.1.6 Body weight	16
	6.2 Distribution of captures	17
	6.2.1 Capture locations 2022-2023	17
	6.2.2 Captures within survey zones 2014-2023	18
	6.3 Habitat	20
	6.4 Fox sightings 2022-2023	21
7	Discussion	22
	7.1 Population dynamics	22
	7.2 Deaths	23
	7.3 Distribution	24
8	The future	25
9	Acknowledgements	25
10	References	26

1. Background

A 10-year study on the hedgehogs in The Regent's Park, the last known breeding population in central London, began in 2014. The background and rationale for the study are set out in the 2014 report; other reports have been published in 2016, 2017, 2021 and 2022 (see references). The aim was to gather data on population numbers and distribution and to develop an evidence-based conservation strategy for this important yet vulnerable group.

Since the studies began, a biannual volunteer spotlighting survey has been conducted in the Park in spring (May) and autumn (September) each year. This report updates the survey results for 2022 and 2023 and provides an overview of the findings from 2014 to 2023. Due to national Covid-19 restrictions in 2020, only the autumn survey was conducted, with some modifications to the method (see references).

The hedgehog studies have been a collaborative effort between The Royal Parks and the Zoological Society of London (ZSL), along with other organizations such as the Garden Wildlife Health project, People's Trust for Endangered Species, Wildlife Trusts, and the Central Royal Parks Wildlife Group. Community engagement has been crucial, involving the recruitment and training of numerous volunteer fieldworkers.

2. Aims of the surveys

The primary aims of the surveys were:

1. to carry out standardised spotlighting surveys of hedgehogs in both May (spring, pre-breeding) and September (autumn, post-breeding) each year to estimate the distribution and population size of hedgehogs in The Regent's Park (not including Primrose Hill).
2. to work with ZSL to investigate and record causes of deaths and injuries of hedgehogs found in the Park.
3. to engage volunteers, the local community and other stakeholders in the surveys.

3. Project partners

1. The Regent's Park Hedgehog Research Project is indebted to a generous gift from The Meyer Family which supported the work during the first years of the project. A dedicated hedgehog fund was established in 2017 that ensures funding for the project through to 2024. This project is a partnership between the following organisations and individuals:
2. **The Royal Parks** is the charity that cares for London's eight Royal Parks (registered charity 1172042). Former project leads were Clare Bowen, Ledy Leyssen, Marion Buggins, Sara Harrison and Tess Pettinger whilst the current lead is Bryony Cross.
3. **The 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. ZSL provide veterinary support during the surveys in May and September each year. The Horticulture Manager, Sven Seiffert, provides guidance, volunteer support and organises the surveys in the Zoo grounds (15 ha). The project team liaises with Dr Chris Carbone and Dr Marcus Rowcliffe, Senior Research Fellows at the Institute of Zoology, concerning camera trapping foxes and hedgehogs within the Park and elsewhere in London.

4. **The Garden Wildlife Health project (GWH)**, co-ordinated by the Institute of Zoology in partnership with the British Trust for Ornithology, Froglife and the Royal Society for the Protection of Birds. It conducts post-mortem examinations and reports on any dead hedgehogs found within the Park.
5. **The Central Royal Parks Wildlife Group** of amateur and professional naturalists and ecologists with an interest in the wildlife within the Central Royal Parks originally identified the need for a hedgehog survey in The Regent's Park and have subsequently provided guidance and volunteer support in the field.
6. **The 'Hedgehog Hero' volunteers.** Each period of fieldwork was supported by a team of more than 100 fantastic volunteers, many of them were repeat volunteers, consisting of individuals with a wide range of backgrounds but sharing a keen interest in wildlife and conservation. Several experienced volunteers again acted as Volunteer Supervisors, leading small teams in the field during the fieldwork.

4. Survey organisation

4.1 Survey dates 2022 and 2023

6th and 13th May 2022

2nd and 9th September 2022

12th and 19th May 2023

1st and 8th September 2023

The survey methods followed those used in previous years (see references). This involved conducting two all-night intensive spotlighting sessions in May (spring), when hedgehogs had emerged from hibernation and were sexually active, and two in September (autumn), after the breeding season, when most young hedgehogs had left the maternal nest and before hibernation. During these sessions, hedgehogs were hand-captured, tagged, and released. Field work was conducted under licence (No. 2020-45862-SCI-SCI) from Natural England.

4.2 Survey zones

For the survey, the Park (166 hectares) was divided into seven zones, consistent with previous years. Primrose Hill (Zone 8) was surveyed in 2015, but no hedgehogs were found, so it has not been surveyed since, and the 2015 results are not included in this report. Zone 2 (Cumberland Green, Gloucester Green, and Zoo Car Park) was split into two sections, 2a and 2b for some analyses (Figure 1). Similarly, Zone 1 was divided into sections 1a and 1b. Certain areas of the Park, including Winfield House, The Holme, and St John's Lodge, could not be accessed during the surveys.



Figure 1 Aerial view of Regent's Park (160 ha) showing boundaries of the survey zones and walk routes (dashed lines). Areas shaded yellow had limited access or no access. OAT=Open Air Theatre.

4.3. Surveyors

Surveys were conducted by volunteers organized by the Royal Parks team, with many of these volunteers being regular participants. In May and September 2022 and 2023 >100 volunteers assisted with each of the surveys. The Zoo (Zone 7) was surveyed by Zoo staff, as has been the case in previous years (see previous reports). The Royal Parks Volunteer Manager liaised with the volunteers and oversaw the scheduling. Training sessions for the volunteers were held online during the week leading up to each survey period, where they were provided with a comprehensive survey guide that included a detailed risk assessment.

4.4 Veterinary support

The Veterinary Services team at ZSL was on standby throughout all fieldwork periods. Any hedgehogs that appeared unwell or injured were safely boxed and taken to the vet team on-site at ZSL. The standard practice was that if the hedgehog could be treated, it was either released back into the Park or placed in the care of experienced hedgehog carer Sue Kidger. In addition to finding sick or injured hedgehogs during the surveys, Zoo or Park staff and members of the public also reported sightings of dead or ailing hedgehogs, which were retrieved whenever possible. All deceased hedgehogs were sent to the Garden Wildlife Health (GWH) project at ZSL's Institute of Zoology, where GWH veterinarians conducted detailed post-mortem examinations to determine the cause of death and any significant underlying conditions. A full tissue archive from each case was preserved for further study as needed.

5 Survey Methods

The survey methods used in 2022 and 2023 followed the same procedures established in 2016, which were slightly adapted from those used in 2014 and 2015 (refer to the 2016 report). Due to Covid-19 restrictions, no survey was conducted in spring 2020, and the autumn 2020 survey was modified slightly as outlined in the 2021 report.

5.1 Spotlighting with Torches and Thermal Imaging Cameras (TIC)

Survey groups, typically composed of five volunteers, conducted systematic nocturnal searches along pre-established routes within each survey zone (see Figure 1). The survey consisted of two shifts on each of two consecutive Friday nights: 21:00-12:00 and 00:30-04:00. Hedgehogs were detected by sound, such as rustling in the undergrowth or noises made during courtship or fighting, or with the use of bright LED Lenser torches. Each group (except in Zone 7) also used a high-specification thermal imaging camera (TIC). The cameras used were FLIR E60s or similar more recent models, with their setup and operation described in Bowen et al. (2020). The search method used by the groups is detailed in previous reports.

Hedgehogs that were found were individually marked with 10 mm lengths of yellow plastic spine sleeves bearing pre-printed numbers, as described by Reeve et al. (2019). Six sleeves with the same ID number were glued to spines at the back of the neck using superglue, and the number was replenished to six if any were found to have been lost upon recapture. For each hedgehog captured, its GPS location, sex, weight, circumference, ectoparasitic load, general health, and the habitat in which it was found were recorded on a standardized form, and the hedgehog released. The hedgehog's location, along with any incidental fox sightings, was also documented on a map.

5.2. Data handling

Location records have been presented using Google Earth Pro maps, with data analysed through Excel, Xlstat, Minitab, and Ranges software. Hedgehog distribution maps, fox sightings and body weights cover the years 2022-2023 to complement the detail in previous reports. In all other aspects, analyses of population demographics, distribution by survey zone and habitat are presented for the entire study period from 2014 to 2023. Hedgehogs weighing 700 g or less, captured during the autumn surveys, are classified as juveniles unless previously marked in an earlier survey. The term "persistence" is used instead of "survival" to describe the duration hedgehogs remain in the surveyed population, as there is insufficient information to determine whether animals that 'disappeared' have died or simply were not recaptured. Given the small sample sizes, life history measures (e.g., productivity, persistence) reported as proportions should be interpreted cautiously. The number of hedgehogs found dead or euthanised each year is also reported. Hedgehogs with severe injuries to their hind limbs or visible bite marks have been considered victims of predation. The number of hedgehogs in the population at the time of a survey is presented as the minimum number known to be alive (MNA), based on the number of individuals captured plus marked individuals not captured but found before and after the survey. No surveys were conducted in spring 2020 due to Covid-19 restrictions, and the autumn surveys involved slight variations to the standard protocols, so these findings should be treated with caution.

Information on detection methods and distances (see Bowen et al. 2020), the longevity of animal markers (see Reeve et al. 2019), capture times during the survey nights, and the nest box survey are not included in this report (see previous reports for details).

6. Results

6.1. Population dynamics

6.1.1. Number of individuals known to be alive at the time of each survey

Between August 2014 and Spring 2023, an average of 1.35 ($N = 17$, $SD = 1.081$) tagged hedgehogs avoided capture during any one survey (6% of the total number of individuals captured). Using this measure, the visual surveys appeared reasonably efficient at finding marked individuals.

Over the course of the study, the average minimum number of hedgehogs alive (MNA) at each survey was 22 ($N = 19$, $SD = 11.0$), but numbers varied considerably between surveys (Figure 6.1.). Two distinct periods can be identified, conveniently separated by the time of the Spring 2020 survey which was not carried because of covid. The first period between Spring 2014 and Autumn 2019 had an average MNA of 29 ($N = 12$, $SD = 7.5$). This included a low in Spring 2016 followed by quite a rapid recovery the following summer. Two peaks in numbers were also found during this period in the Autumns of 2014 and 2017 (Figure 6.1). These demographics have been explored in more detail in previous reports. The second period between Autumn 2020 and Autumn 2023 averaged an MNA of 12 hedgehogs per survey ($N = 8$, $SD = 5.4$) encompassing a continuous decline between Autumn 2020 and Spring 2023 reaching a low of 6 hedgehogs, followed by a very small upturn in Autumn 2023 (Figure 6.1).

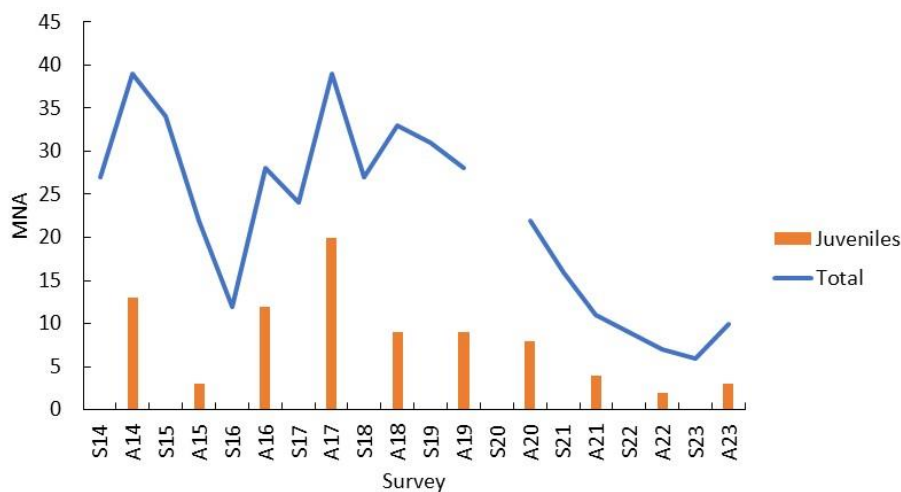


Figure 6.1 Minimum Number of hedgehogs known to be Alive (MNA) at the time of each survey (season-year). S = Spring, A = Autumn. No survey was carried out in Spring 2020.

With the exception of Autumn 2022 and Spring 2023, fewer adult males were known to be present at the time of each survey than females (Figure 6.2). This was particularly the case at the time of the population low in Spring 2016 and through the period from Autumn 2019 to Spring 2021. The reasons for this disparity are not known but may indicate differences in survival between males and females.

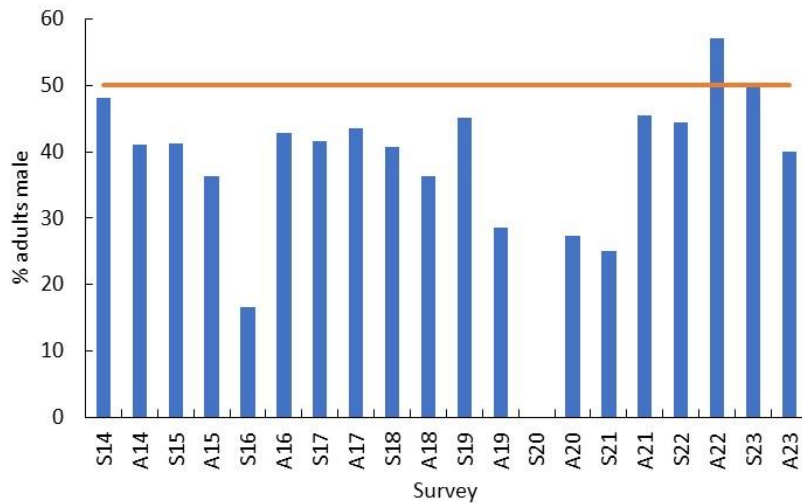


Figure 6.2 Adult sex ratio expressed as the percentage of males present in each survey. Horizontal line represents an equal number of adult males and females.

6.1.2. Recruitment

The autumn surveys provide evidence that breeding took place each year. Over the whole study 34% of the total numbers captured each autumn were juveniles ($N = 10$, $SD = 9.0\%$) with a maximum of 51% in 2017. In fact, the highest number of juveniles captured, both in total and per adult female, occurred in autumn 2017, indicating a relatively strong recruitment year. In contrast, autumns 2015, 2021, 2022 and 2023 saw the lowest juvenile counts. 2015 had the fewest juveniles per adult female, preceding a population decline in spring 2016 (Figure 6.3). The recruitment of juveniles per adult female was better in 2021, 2022 and 2023 but based on very small numbers. Except for 2014, the juvenile-to-adult female ratios during autumn in other years were relatively low, ranging from 0.55 to 1.00.

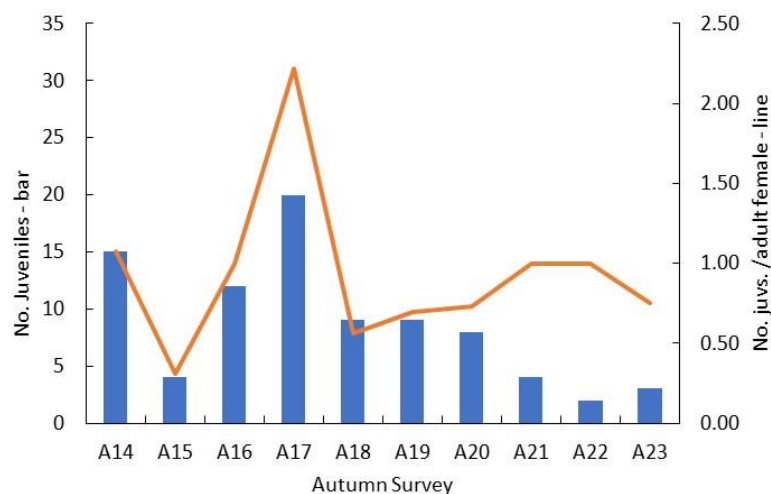


Figure 6.3 Number of juveniles captured per adult female in the autumn surveys, and number of juveniles captured and the per cent of juveniles of MNA in each survey.

6.1.3 Seasonal persistence

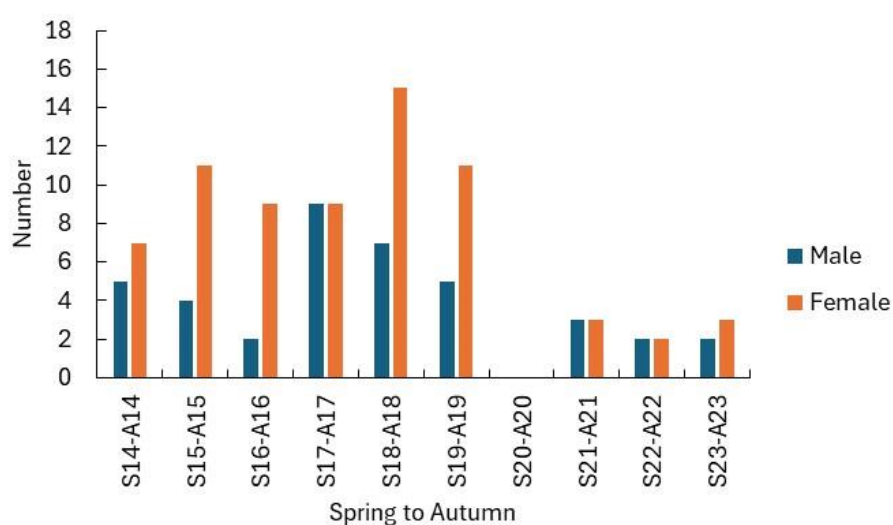
The numbers of individuals that persisted over the summer or winter were small, frequently in low single figures (Figure 6.4). The very small numbers towards the end of the study reflect the declining and small population at that time. Between spring 2014 and Autumn 2019 more females (Mean = 10.3, N = 6, SD = 2.73) than males (Mean = 5.3, N = 6, SD = 2.42) persisted over summer (Mann-Whitney U = 2.5, P = 0.015). There was also a significant difference among males and females, adults and juveniles that persisted overwinter (Kruskal-Wallis K = 11.175, P = 0.11, Table 6.1). More adult females persisted than adult males with considerably fewer juvenile males and females.

Table 6.1 Mean number of male and female adults and juveniles that persisted overwinter between 2014 and 2019 (N = 5) and P values from pairwise comparisons between each group (Dunn's procedure, two-tailed tests).

Group	Mean	SD	Juv male	Ad fem	Juv fem
Ad male	4.0	2.45	0.447	0.030	0.514
Juv male	2.4	2.19		0.003	0.913
Ad fem	9.2	1.30			0.005
Juv fem	2.8	3.27			

Turning to the percentage of hedgehogs that persisted, there was no difference in the percentage of males (Mean = 61 %, N = 9, SD = 24.8) or females (Mean = 65 %, N = 9, SD = 25.6) that persisted over summer (Mann-Whitney U = 36.5, P = 0.746). The percentage of females that survived the winter were generally better than males and adults better than juveniles, although the differences were not significant (adult males Mean = 64%, N = 8, SD = 25.7, adult females Mean = 73%, N = 8, SD = 16.9, juvenile males 36%, N = 8, SD = 35.7, juvenile females Mean = 46%, N = 8, SD = 31.0, Kruskal-Wallis K = 6.918, P = 0.075).

(a) Summer persistence



(b) Winter persistence

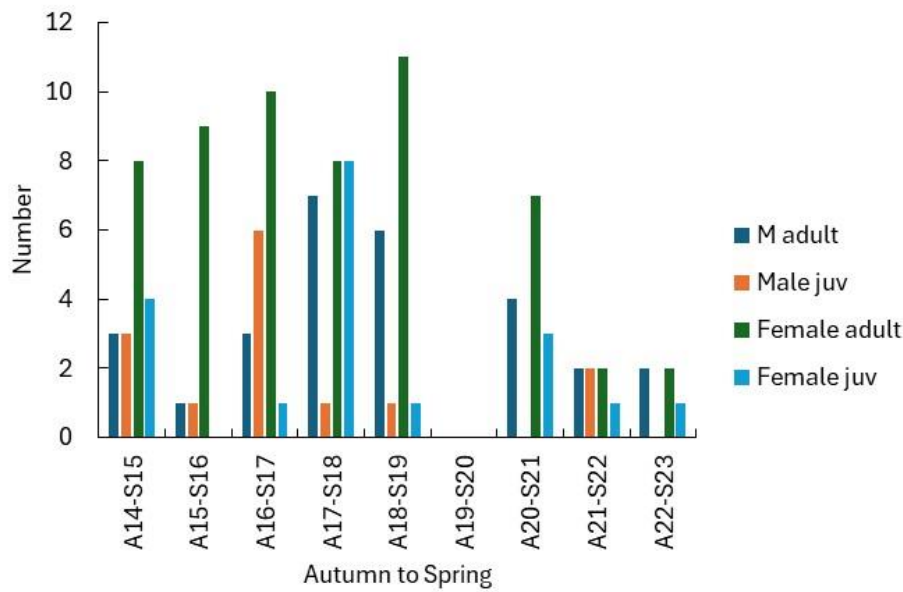


Figure 6.4 Number of hedgehogs that persist in the population (a) over summer and (b) over winter each year. No survey was carried out in spring 2020. M = Adult male, F = adult female, J = juvenile. A = Autumn, S = Spring.

6.1.4. Persistence curves

The persistence or survival of juvenile hedgehogs captured in the autumn have been pooled from 2014 to 2021 and presented in Figure 6.5. The sample sizes are not particularly large, but they show that 64% of males and 58% of females disappeared from the population within their first year of life. Seventeen per cent of males and 20% of females survive two years and 3% of males and females three years. After the first year, these figures are lower than those reported by Morris (1969) for post-weaned animals and much lower than those reported by Rasmussen et al. (2023) based on road-killed hedgehogs collected in Denmark in 2016 – these curves are shown in Figure 6.5.

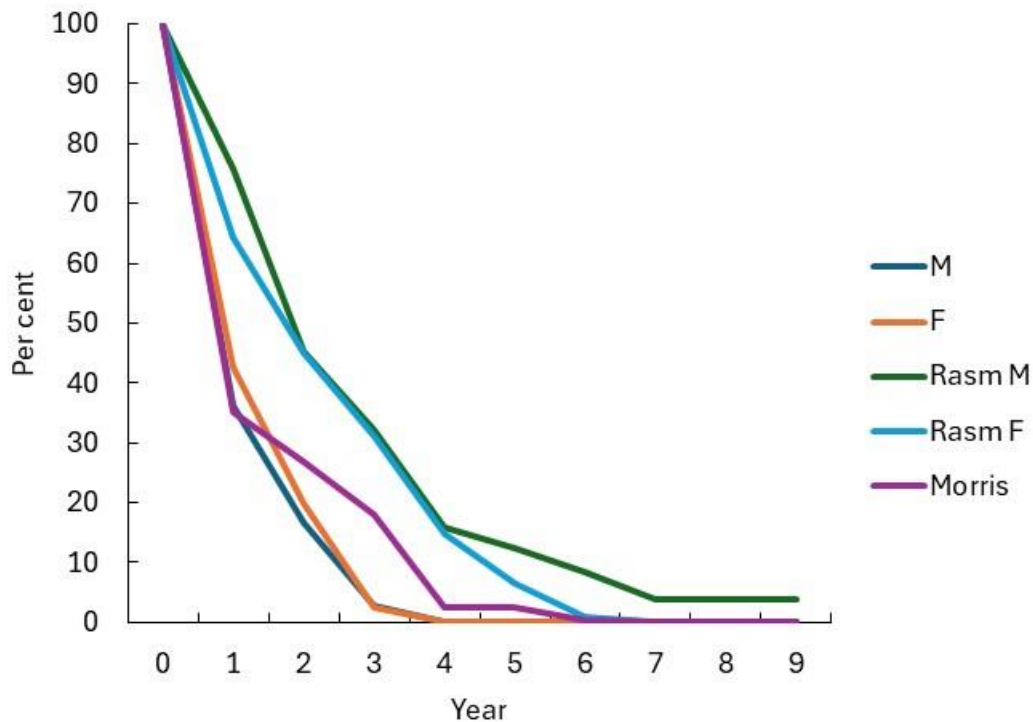


Figure 6.5 Persistence of cohorts of male and female juveniles captured each autumn between 2014 and 2021 combined data. M = Male (N = 36), F = Female (N = 40). Rasm = Rassmussen et al. (2023), Morris = Morris (1969).

6.1.5. Deaths

During the 10-year study, eighty-eight hedgehogs were found dead or injured and had to be euthanised. In addition, six injured animals received veterinary treatment; two were rehomed with a caregiver, and four were released back into the Park. The rest were either found dead or euthanised due to severe injuries, such as serious leg wounds. For some of the deaths, details such as sex, age, whether the animal was marked, and the exact location where they were found are unknown. In addition, the cause of death could not be ascertained for some individuals. For the others, deaths were attributed to roads, predators, leg injuries, or various other factors such as disease or drowning (Figure 6.6). It is believed that most leg injuries were caused by predator bites, likely from foxes or possibly dogs. In Figure 6.7(a), results for predation and leg injuries have been combined and show that, where the age was known, slightly more juveniles than adults died as a result of predation. However, when the total number of deaths in these age classes is taken into account, 92% of juvenile deaths were attributed to predators compared with 44% in adults (and 29% of bodies that could not be aged). Overall, more deaths were recorded in summer than spring, with the fewest in autumn (Figure 6.7(b)).

Fifty-two per cent of dead hedgehogs were tagged, representing approximately 27% of all the animals tagged during the study.

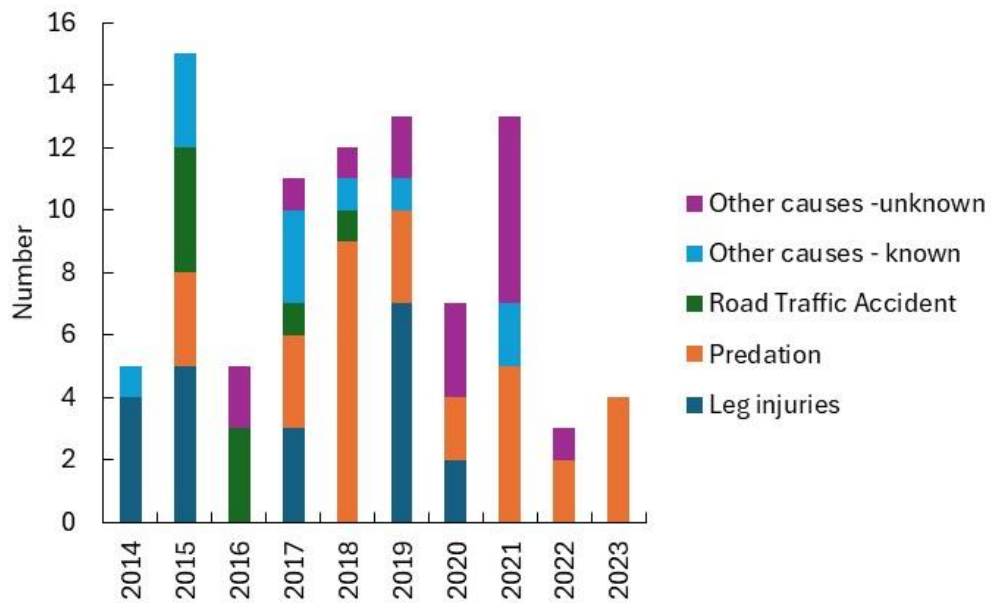
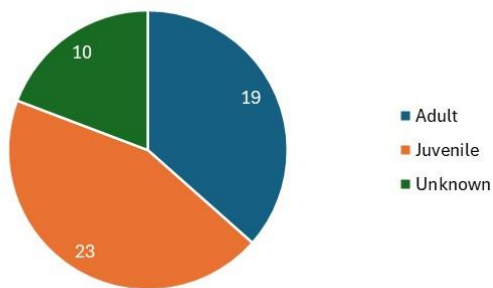


Figure 6.6 Number of known deaths reported in the Park each calendar year.

- Age



- Season

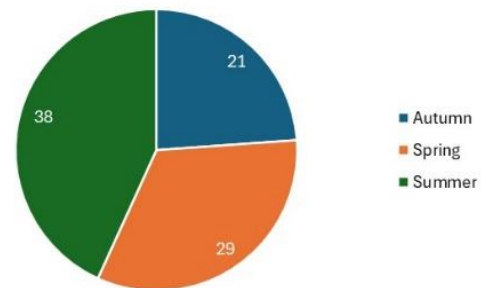
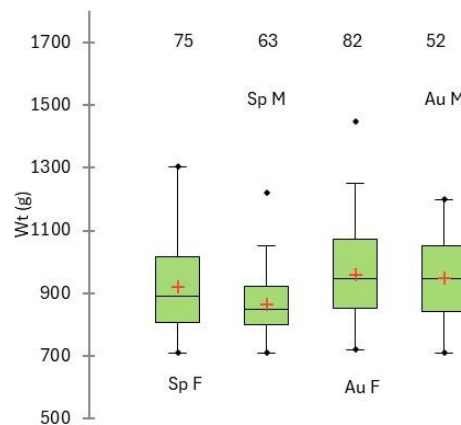


Figure 6.7 (a) Number of deaths attributed to predation and leg injuries, both likely caused by foxes, (b) Number of deaths according to season.

6.1.6. Body weight

Hedgehog body weights vary from season to season and among years; overall, on average adult females weigh more than adult males and autumn adults weigh more than spring adults (Figure 6.8(a), Gurnell et al. 2021). Here we also present the body weights for the last two years of the study (Figure 6.8(b)). Sample sizes were too small to carry out any statistical analysis and it is not possible to read too much into the results. Individual body weights were quite variable but in line with previous findings. There does not appear to be any noticeable trend in body weights at this time of low population numbers. However, it is noticeable, and in contrast to previous years, that on average adult males tended to weigh slightly more than adult females within each season. To illustrate how the weight of individuals varied within a survey, two lightweight females were captured in spring 2022 (600 g and 655 g), with the other three females captured considerably heavier (1020 g, 900 g and 810 g).

(a) 2014-2023



(b) 2022-2023

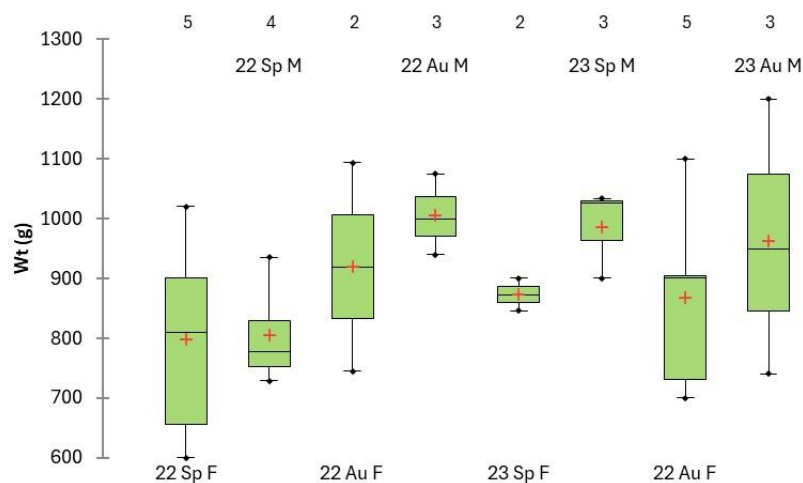


Figure 6.8 Box and whisker plots of adult body weight (g) of males (M) and females (F) according to year and season. (a) 2014-2023, (b) 2022-2023. Sp = spring, Au = autumn. + = mean, horizontal bar = median, boxes = upper and lower quartiles, upper whiskers = maximum, lower whisker = minimum. Numbers above plots = sample size.

6.2 Distribution of captures

6.2.1 Captures 2022-2023

Population numbers were low in 2022 and 2023 and nearly all of the capture locations in spring and autumn of these years were in the north-east quadrant of the Park and with only the occasional capture outside this area (Figure 6.9). In particular, these captures were clustered in and around the Zoo (Zone 7, Zone 2a and the top of Zone 3), and an area in the middle of the Park (Zone 4 and the bottom of Zone 3) (see inset Figure 6.9). Thus, it appears that many hedgehogs lived in or at the edge of the Zoo and moved onto the open parkland to feed at night.

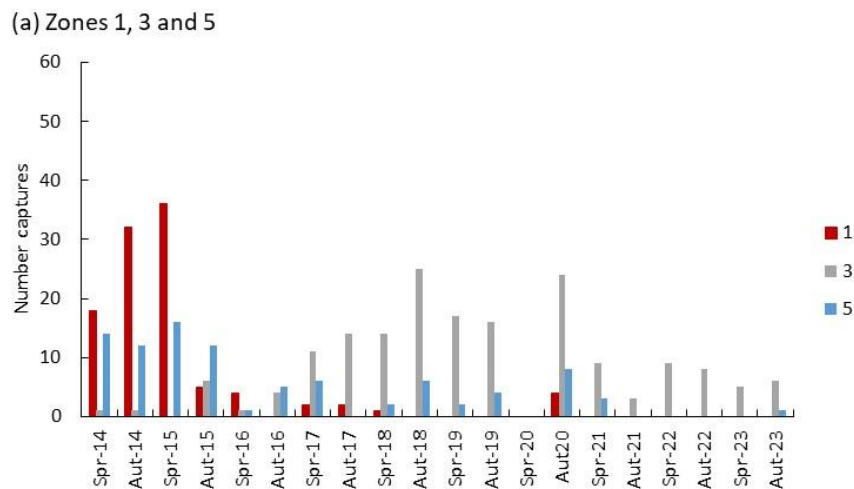


Figure 6.9 Individual capture locations 2022-2023. Yellow = spring 2022, red = autumn 2022, blue = spring 2023, green – autumn 2023. Insert bottom left are the survey zones.

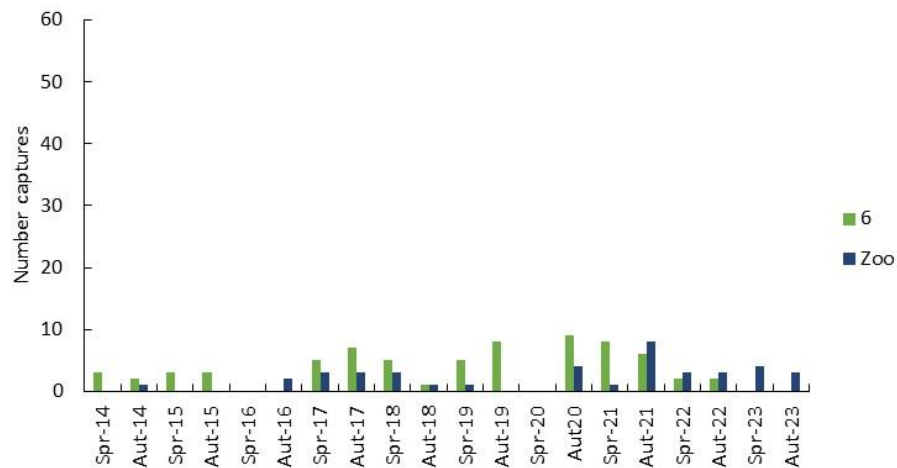
6.2.2 Captures in survey zones 2014-2023

Since the study began in 2014, there has been a significant shift in the distribution pattern of captures, as detailed in previous reports. This change is most clearly observed by analysing captures within specific survey zones. Figures 6.10 and 6.11 show the numbers and the relative (%) numbers of captures in each zone respectively and should be viewed together because of the considerable differences in numbers of hedgehogs captured throughout the study. In 2014 and spring 2015, Zones 1, 2, and 5 were identified as "hot spots" with the highest number of hedgehog captures (refer to earlier reports). However, between spring and autumn 2015, there was a sharp decline in captures in Zone 1, and to a lesser extent in Zone 5. Zone 1 did not recover, and there were only a few captures in Zone 5 after. Conversely, captures in Zone 2 increased and continued to be a "hotspot" until autumn 2020. Within Zone 2a, the Zoo Car Park was a "local hotspot" (Figure 6.12). The Car Park accounted for 25% of all captures in autumn 2014 and 20% in spring 2015. However, no hedgehogs were found in the Car Park from 2020 until the end of the study in 2023. Since 2014, the Car Park habitat has experienced considerable disruption due to major works, including the replacement of water mains and the construction of a Lorry Holding Park for the HS2 project at nearby Euston Station (see the 2017 Report for details).

In other areas of the Park, captures in Zone 3 have increased from 2017, mainly around the peripheral areas. Capture numbers in Zone 4 have fluctuated, while captures in Zone 6 and the Zoo grounds (Zone 7) remained low until autumn 2020 and spring and autumn 2021, when they showed an increase (Figure 6.10). The importance of the Zoo and its surrounds towards the end of the study has been highlighted above.



(b) Zones 6 and 7 (Zoo)



(c) Zones 2 and 4

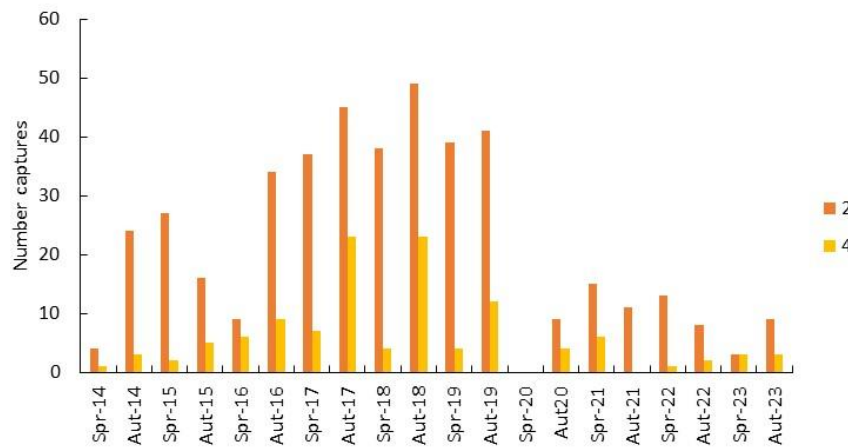


Figure 6.10 Numbers of captures in each zone for spring and autumn surveys, 2014-2023. No survey was carried out in spring 2020. (a) Zones 1 (1a and 1b combined), 3 and 5, (b) Zones 6 and 7 (Zoo), (c) Zones 2 (2a and 2b combined) and 4. Bars drawn to the same scale. The Zoo Car Park in Zone 2 was not surveyed in spring 2014.

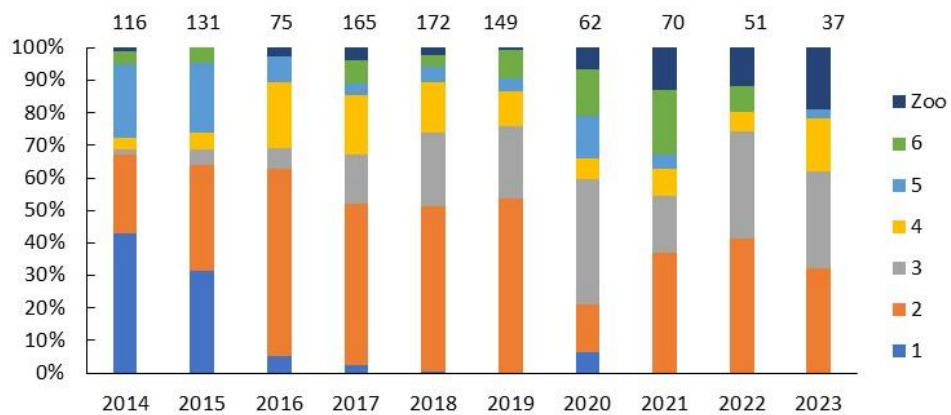


Figure 6.11 Proportion of captures in each zone

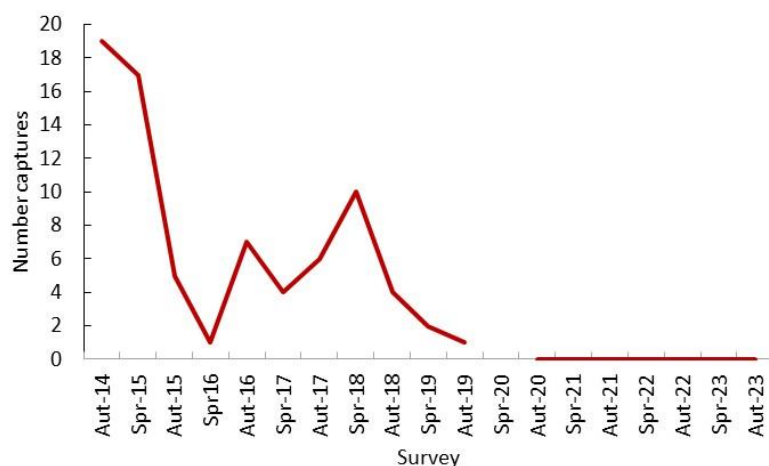


Figure 6.12 Numbers of captures in the Zoo Car Park.

6.3 Habitat

Since the study began two-thirds of captures have occurred in short grass (less than 10 cm high) (Figure 6.13). Ten percent occurred in grass over 10 cm high and six percent on sports pitches with relatively few captures in other habitat categories. Visibility for detecting hedgehogs with torches and thermal imaging cameras was good on the open grassland areas and high numbers of captures reflect this. Even so, the findings from radiotracking studies carried out in 2014 and 2015 (see earlier reports) found that grassland was particularly important for foraging at night whereas scrub, planted shrubberies and hedgerows were important as daily nesting habitats.

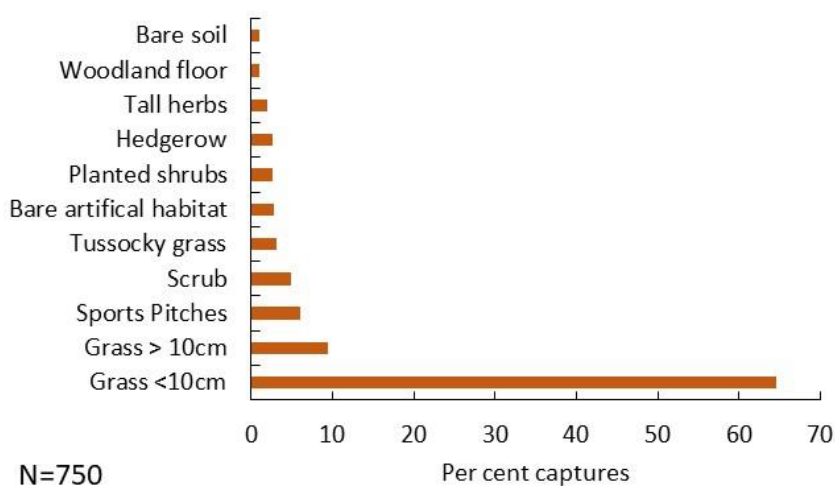


Figure 6.13 Percent of captures in each habitat 2014-2023.

6.4 Fox sightings 2022-2023

The locations of fox sightings recorded by volunteers during night-time surveys in 2022 and 2023 are shown in Figure 6.14. As in previous years, foxes are seen throughout the Park with some clustering to the north and east in 2022, a cluster at the interface of zones 3, 2 and 4 in spring 2023 and a fairly widespread distribution in autumn 2023. Fewer sightings were recorded in zones 5 and 6 generally. These distribution plots do not represent individual foxes but where they focus their activity. Clearly, foxes explore over wide areas inside and probably outside the Park and individuals would be sighted several times in different locations during the night.

(a) Spring 2022



(b) Autumn 2022



(c) Spring 2023



(d) Autumn 2023



Figure 6.14 Distribution of fox sightings in spring and autumn 2022 and 2023

7. Discussion

As an estimate of population size, the report presents the minimum number of hedgehogs known to be alive (MNA) at the time of each survey. This approach accounts for hedgehogs that were captured before or after a particular survey but not during it, meaning they were missed in that specific survey. However, the number of individuals missed was relatively small and mostly female (mean per survey: female = 1.18, SD = 1.074, N = 17; male = 0.18, SD = 0.393, N = 17), with very few hedgehogs missed on two or more occasions. These findings suggest that the survey methods were generally effective in capturing most hedgehogs present in the Park during the survey periods. It is acknowledged that hedgehogs may 'appear' and 'disappear' between surveys, such as young born late in the season who are not yet foraging outside the maternal nest when the autumn survey occurs in September.

It is worth noting that the interval between spring and autumn surveys (over the summer) was in the order of 110 days whereas between autumn and spring surveys (winter) it was 250 days. Winter includes the hibernation period, typically lasting from October to April, though this can vary, with some hedgehogs remaining active into late November and others awakening as early as March (Reeve 1994). There is currently no information on hibernation patterns of hedgehogs in Regent's Park. However, if for the sake of argument, we assume that the hedgehogs hibernate from November to mid-March (incl.) for a total of 135 days, the number of days hedgehogs were active between the autumn and spring surveys was approximately 115 days. This is similar to the number of days active between spring and autumn.

The standard twice-yearly survey schedule was disrupted due to Covid-19 restrictions, preventing a survey in spring 2020 and resulting in slight alterations to the methodology in autumn 2020. Despite Regent's Park remaining open to the public during the lockdown, with very many daily visitors present, outdoor venues such as cafes were closed. There is no clear reason to suggest that these events directly impacted the hedgehog population. However, even though it is likely just a coincidence, there has been a decline in hedgehog numbers since 2020, along with some shifts in their distribution and the habitats in which they were found.

7.1 Population dynamics

For the first six years of the study (2014-2019), the hedgehog population in Regent's Park was small but seemed relatively stable fluctuating around an average of 29 individuals. Little is known about what the minimum size of a hedgehog population (the so-called minimum viable population size or MVP) should be for it to survive in the wild. However, Moorhouse (2013) addressed this problem using demographic values from the literature and a program called Vortex (<https://scti.tools/vortex/>) and came up with an MVP of from 32 to 60 individuals for urban hedgehogs². Even though the lower figure of 32 intuitively feels small and is probably no more than a crude approximation, it is still higher than the average of 29 individuals reported here. The inevitable interpretation from this is that the population during this period was very vulnerable to variations in the environment such as changes in the weather, habitat or food availability. In fact, in spring 2016, the population did decline to a low of 12 individuals which was concerning at the time, but it rebounded within a year. However, from autumn 2020, the numbers steadily declined to a low

² This is considerably less than an estimated MVP of 120-250 individuals for rural populations of hedgehogs.

of six individuals in spring 2023, with only a small upturn by autumn 2023, the end of the study. At the time of writing, it is uncertain whether the population will recover this time.

The hedgehog population in the Park is thought to be isolated from other populations in London, such as the one at Hampstead Heath to the north (see previous reports). Despite this, there is no clear reason why the population remains so small. Based on the area and habitat available, the Park could potentially support three to four times the 2014-2019 average number. A larger population would be more resilient to environmental and demographic changes, as well as catastrophic events. The small population size may be leading to inbreeding depression, which could further reduce its numbers, potentially leading to an extinction vortex, although there is limited direct evidence for this. These issues have been covered in previous reports (see References at end), so they will not be repeated here.

Reproduction took place every year with recruitment leading to higher population numbers in the autumn than the spring, except towards the end of the study when the population was small. However, the population has never shown a sustained growth period lasting two years or more. Recruitment depends on factors such as the number of adult females that breed, the size of litters, and the survival rate of young hedgehogs through infancy until they become independent members of the population. Moderate recruitment occurred in the years 2014, 2016 and 2017 but it was low in other years and especially at the end of the study in 2021, 2022, and 2023 when only 4, 2 and 3 in juveniles were captured respectively. In the autumn of 2017, 2.22 young were captured per adult female which is consistent with the other measures that indicate this was the best recruitment year. In all other years one or less than one juvenile was captured per adult female, which is insufficient to enable the population to grow. It should be pointed out, however, that the figures are likely to underestimate the actual numbers of juveniles in the population because some juveniles may have been too young to be captured during the autumn surveys (and perhaps some early born young had gained sufficient weight to be >700 g by September). Nevertheless, recruitment appears low compared to a Swedish study, where the average number of independent, surviving juveniles per adult female ranged from 1.33 to 4.13 annually (Kristiansson, 1990).

Generally, hedgehogs are promiscuous, with males expanding their home range in spring and summer in search of mating opportunities. The general trend in Regent's Park has been a female-biased adult sex ratio, except towards the end of the study with low numbers of individuals. This reflects that adult female persistence was better than adult male persistence, which in turn was greater than juvenile persistence. There was little difference in summer persistence between adult males (61%) and adult females (65%) which was also to adult male winter persistence (64%). However, adult female winter persistence was slightly higher (73%) but juvenile male (36 %) and juvenile female (46 %) persistence was considerably lower. Because of small numbers, it is not possible to identify more precise patterns in persistence across the study. However, what is clear is that the persistence or survival of hedgehogs at The Regent's Park is considerably lower than that reported in other studies (Morris 1969, Rasmussen et al. 2023) with only 17% of males and 20% of females surviving two years falling to 3% of both males and females to 3 years of age. Thus the number of breeding opportunities for females is restricted with very few having the opportunity to breed over three years.

7.2. Deaths

Throughout the study period, several hedgehogs have been found dead or in such poor condition that they had to be euthanised. Given the small population size, these known deaths are particularly concerning, and of course many more hedgehogs die without being detected. Nonetheless,

analysing the known deaths offers valuable insights. More of the deceased hedgehogs were discovered in the summer than the spring, with fewest found in autumn. Of the ~190 hedgehogs tagged during the study, over a quarter of them (27%) were found injured, sick or dead. When the cause of death could be determined, predation was responsible for 44% of adult deaths and 92% of juvenile deaths, likely due to foxes (but dogs cannot be ruled out). Although the predation of nestlings or young hedgehogs could be critical as it could hinder the population's growth and recovery, the surveys were not designed to investigate these important factors. Nine hedgehog deaths were due to road accidents between 2015 and 2019, although no such incidents were reported between 2019 and 2023 when numbers of individuals were small. Other causes of death included lung infections, ear infections, unspecified illness, and drowning.

7.3 Distribution

The distribution of hedgehogs throughout the study has been previously addressed in earlier reports. A significant shift occurred during the summer of 2015, with hedgehogs disappearing from the southern section of the Park (Zone 1). Additionally, there has been a noticeable decline in captures in the western area (Zone 5) since that time. At the beginning of the study, Zone 2, located in the eastern part of the Park, was a favoured area and remained so until August 2019. Notably, Zone 2 includes the Zoo Car Park (approximately 2.6 hectares, minus 0.8 hectares of tarmac), which was identified as a local hotspot in 2014 and 2015, accounting for over 20% of all captures in this small area. However, starting in spring 2018, the number of captures in Zone 2 and the Zoo Car Park began to decline, with no individuals captured in the Car Park over the past four years. The disturbance, habitat loss, and fragmentation since 2017, when Thames Water established a compound in the Car Park (refer to the 2017 Report), may have contributed to the decline in hedgehogs in this area. However, since the works only impacted the eastern end of the Car Park, and there has also been a reduction in captures across Zone 2, it is likely that other factors contributed to the decline. Other notable trends include a relative increase in captures around the sports fields since the study began, and a rise in captures in Zone 6 and Zone 7 (the Zoo) since August 2020. In fact, the Zoo grounds and the areas around the Zoo seem to have been a focus for the hedgehogs in the last three or four years. It could be suggested that the Zoo with its surrounding wrought iron fence offers a degree of protection for the hedgehogs from foxes and dogs, although foxes can be found within the Zoo grounds.

Taking the Park to be 166 ha in area, the average of 29 individuals per survey over the first 6 years approximates to 5.7 ha per individual (or 18 hedgehogs km⁻²). However, as described above, the hedgehogs are far from evenly distributed across the Park. The density of hedgehogs in 2022 and 2023 in the north-east quadrat of the Park (~60 ha) approximates 6 ha to 10 ha per hedgehog (or 10 hedgehogs km⁻² to 17 hedgehogs km⁻²). Thus, there is not a great deal of difference in the density of hedgehogs across the study; it is simply that as the numbers reduced the population range contracted, maybe to what is their most favourable part of the Park. It is not easy to tease apart whether it is changes in habitat or changes in demographics which has resulted in the situation at the end of the study. However, there is one clue that the former may have some importance. There have been two important declines in numbers of hedgehogs in The Regent's Park during the 10-year study. The first was the decline in numbers to the low in spring 2016, and this was accompanied by changes in distribution with hedgehogs disappearing from the southern and western areas of the Park. Although population numbers rebounded over the following year, hedgehogs did not repatriate these areas. The second critical moment was the decline in numbers from 2020 to 2023, but hedgehogs were predominately living in the north-east quadrat during this time. Some of the factors that may have influenced the changes in numbers and distribution have been considered in more detail in previous reports.

None of these studies could have been carried out without the dedicated help of the large number of volunteers who worked on the project over the 10 years.

8. The future

The original aim of the project when established in 2014 was to carry out biannual surveys of the hedgehogs in The Regent's Park until 2023. However, as a result of the declining number of hedgehogs in the population between 2020 and 2023 and the small numbers remaining at the end of this period, the project partners have been evaluating the evidence gathered from the ten years of survey work, together with other research findings, to inform decisions about the way forward to conserve this fragile hedgehog population. As part of that review, and to maintain continuity with the previous 10 years, the standardised biannual surveys of the Park, using spotlighting and thermal imaging cameras, are continuing in 2024 and are likely to take place in 2025. These and new conservation initiatives will be the subject of future reports.

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This project has only been possible because of the support of our brilliant volunteers...thank you to everyone who has helped.

10. References

Reports:

The following reports on the hedgehog studies in Regent's Park can be found at:

<https://www.royalparks.org.uk/managing-the-parks/conservation-and-improvement-projects/hedgehogs/hedgehog-research-reports>.

Gurnell, J., Reeve, N., Bowen, C. & The Royal Parks Foundation (2015) A Study of Hedgehogs in The Regent's Park, London – May and September 2014. The Royal Parks Foundation, London.

Gurnell, J., Reeve, N., Bowen, C. & The Royal Parks Foundation (2016) A Study of Hedgehogs in The Regent's Park, London – May and September 2015. The Royal Parks Foundation, London.

Gurnell, J., Reeve, N., Bowen, C. & The Royal Parks Foundation (2017) A Study of Hedgehogs in The Regent's Park, London – May and September 2016. The Royal Parks Foundation, London.

Gurnell, J., Reeve, N., Bowen, C., Pettinger, T. Cross, B. & The Royal Parks (2021) Surveys of hedgehogs in The Regent's Park London 2014-2020.

Gurnell, J., Reeve, N., Cross, B. & The Royal Parks (2022) Surveys of hedgehogs in The Regent's Park London 2014-2021.

Other references:

Bowen, C., Reeve, N., Pettinger, T. & Gurnell, J. (2020) An evaluation of thermal infrared cameras for surveying hedgehogs in parkland habitats. *Mammalia* 84: 354-356.

Kristiansson, H. (1990) Population variables and causes of mortality in a hedgehog population (*Erinaceus europaeus*) in southern Sweden. *Journal of Zoology, London* 220: 391-404.

Moorhouse, T. (2013) Population viability analysis of hedgehogs in rural and urban habitats, Prepared for the People's Trust for Endangered Species & the British Hedgehog Preservation Society: 36.

Morris, P. A. (1969) Some aspects of the ecology of the hedgehog (*Erinaceus europaeus*). Ph.D. Thesis, University of London

Rasmussen, S. L., Berg, T. B., Martens, H. J. & Jones, O. R. (2023) Anyone Can Get Old. All You Have to Do Is Live Long Enough: Understanding Mortality and Life Expectancy in European Hedgehogs (*Erinaceus europaeus*). *Animals* 13: 626.

Reeve, N.J. (1994) *Hedgehogs*. T & A D Poyser.

Reeve, N., Bowen, C. & Gurnell, J. (2019) An improved identification marking method for hedgehogs. *Mammal Communications* 85: 1-5.