ASSESSING THE EUROPEAN HEDGEHOG'S (*ERINACEUS EUROPAEUS)* STATUS, BEHAVIOURAL ACTIVITY AND HOME RANGES IN A RURAL AND URBAN SETTING, WITH SPECIFIC INTEREST ON THE ISLAND OF JERSEY, UK

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JICAS JERSEY INTERNATIONAL CENTRE OF ADVANCED STUDIES

Jersey Hedgehog Preservation Group

Contents:

Abstract:-

The European Hedgehog *Erinaceus europaeus* has seen population numbers decline for several decades despite being listed as *Least Concern* on the IUCN Redlist. The quoted 46% reduction in individuals in 13 years has promptly had the species added to the UK's own Red List for species at risk of local extinction in the future. These regional declines have led to studies reviewing hedgehog numbers on a more local scale, such as this study on hedgehogs in Jersey, Channel Islands. Alongside analysing historical data stored at multiple organisations in Jersey, this study included a radio-tracking survey undertaken on the Island to assess behavioural changes in urban and rural-dwelling hedgehogs. Using the latest Biotracker equipment, multiple surveys were conducted during initial activity in the late evening and early morning hours. It is illustrated through visual observation and statistical analysis that hedgehogs still have their favoured vegetational landscapes to feed, seek refuge and hibernate in. However, due to the differing, ever-present pressures in both urban and rural settings, it is not easy for them to settle in one location for extended periods, with frequent and often fatal disruptions. This study explores ways to mitigate these issues and suggests methods to support and bolster population numbers in Jersey and across the continent.

Keywords: - Behaviour; Dispersal; Ecological trap; Erinaceidae; Invertebrates; Radio-tracking; Rural; Small Mammal; Urban.

I. INTRODUCTION

1.1 Species overview

The European hedgehog (*Erinaceus europaeus*) is a species of hedgehog native to the European continent, originating from Italy and the Iberian Peninsula, after which it moved Northwards to Scandinavia and later migrated in a westerly direction into the United Kingdom (Harris and Yalden, 2008). The species are mainly brown in colour, with a small blonde contingent comprising approximately 25% of the entire population, known commonly as albino hedgehogs, which are very rare and are only found widespread on the Channel Island of Alderney and North Ronaldsay, in Scotland (Morris and Tutt, 1996). *Erinaceus europeus* are classified as insectivores, as their diet consists of many invertebrates, including crickets, earthworms and beetles (Roberts, 2011).

Figure 1: The European Hedgehog (*Erinaceus europaeus*), foraging for food (Arndt, 2023)

The Species is listed as Least Concern on the IUCN redlist, despite global population numbers rapidly declining (IUCN, 2023), and it is now classified as vulnerable to extinction on the UK's Red List, suggesting it is at risk of local extinction in the future. Wembridge and Langton (2011) stated that there had been an estimated 25% decline in British hedgehog populations in the last decade due to a high number of road kills, increased predation and being out-competed by other species, such as the badger of fox. Despite this, it is considered in certain places globally as a pest, especially in regions where it has been introduced outside of its natural, native home range. This opinion is widespread throughout New Zealand, where it was introduced in the late nineteenth and early twentieth century and is known to prey upon native invertebrate fauna

(Crawley, 1985), including the eggs of ground nesting birds, snails and certain lizards. However, in many other regions of the world, it is considered a harmless, charismatic creature, with people encouraging its appearance in private gardens due to its endearing character and consumption of garden pests.

1.2 Global population declines

There has been a plethora of evidence in the literature to suggest that Hedgehog populations have declined for quite some time (Rasmussen *et al.*, 2019). These losses are driven by vehicle-related accidents, predation from badgers, habitat fragmentation or intensified agricultural practices (Rasmussen *et al.,* 2019). These causes play their role in the observed population declines; however, habitat fragmentation is critical for a hedgehog's survival. Creating a 'Hedgehog highway' permits access to multiple resource areas and generates a passage for individuals to locate food, water and shelter in a private garden for example. This solution comprises tiny, insubstantial passageways enabling them to travel along and through small holes at the foot of fence panels, creating a thoroughfare and preventing individuals from becoming confined. Population numbers have fallen by approximately 46% in Britain in just 13 years to 500,000 individuals (Rasmussen, 2023). This decline is a consequence of the above-stated impacts, which the species suffers dearly.

Increased urbanisation and anthropogenic pressure is the single greatest threat to biodiversity globally. However, hedgehogs are a species that can thrive in urban regions, given a bit of help. They are shown to successfully utilise and reach higher densities in green spaces neighbouring metropolitan areas than in rural landscapes where resources are becoming sparser (Taucher *et al.,* 2020). This decision might seem counter-intuitive due to the presence of anthropogenic pressures; however, in urban areas, there is a more significant presence of anthropogenic food availability (Contesse *et al.,* 2004; Doncaster *et al.,* 1990), a higher standard of habitat quality (Egli *et al.,* 2004; Zingg, 1994), better climatic conditions for survival (Pickett *et al.,* 2001) and more availability of suitable nesting vegetation (Baker & Harris, 2007). Therefore, rural-based hedgehogs have suffered dearly in recent decades, and these are the areas where most observed losses have arisen. As such, urban regions are given the handle of 'shelters' or 'sanctuaries' for hedgehog populations, more commonly referred to as a source population, like in a metapopulation.

Hedgehog preservation 'hospitals' are being built in many countries worldwide, acting as a safety net for the increasing numbers of injured or sick individuals. For example, such an operation has been run in York since the early 1990s and runs under the stewardship of the Royal Society of the Prevention of Cruelty to Animals (RSPCA) (Bunnell, 2009). As is similar to any other Hedgehog sanctuary, the efforts in York use a local Veterinary Practice to administer any medical treatment if required. Finally, these sanctuaries' sole purpose is to rehabilitate the individuals before returning them to the wild near the obtained location.

Projects are set up globally to help boost hedgehog population numbers, attempting to reduce individual mortalities. In Denmark and the United Kingdom, solutions are highly sought after, building upon prior research, to reverse the rapid declines witnessed in the 21st century. As a result, the former created the 'Danish Hedgehog Project', designed for volunteers to record sightings (and deaths) of hedgehogs. Some 400 volunteers were involved, collectively documenting 700 sightings of dead hedgehogs within the set period, with the perceived cause of death noted for each case (Rasmussen, 2023). In addition, the project was also set up to assess and analyse hedgehog behaviour, where they found that male hedgehogs tended to generally have a more extensive home range than females (Rasmussen, 2023).

1.3 Hedgehogs in Jersey

Hedgehogs were introduced to Jersey in the mid-1800s (States of Jersey, 2023) at about the same time as their small mammal companion, the red squirrel. They face many threats on the island, including anthropogenic impacts and urbanisation. Still, they do not face any natural predators as they do in the UK, with the presence of foxes and badgers (States of Jersey, 2023). Another major threat Jersey-residing hedgehogs face is the annual Branchage event, an implemented law that certifies that perceived vegetation overgrowth surrounding footpaths and roads is curtailed. This affair causes massive issues for hedgehogs when they are nesting in hedgerows or grass verges during the daytime, with many strimmer-related injured hedgehogs being admitted to the local veterinary practices or the Preservation Group with severe wounds.

Figure 6 shows the respective heat maps for the hedgehog population in Jersey following public surveys in 2007, 2012 and 2023. There has been a steady decline in population numbers, and their territories are becoming smaller and even more fragmented. From inspection, individuals tend to prioritise occupying urbanised regions, likely due to the presence of anthropogenic food sources, such as in St Brelades and St Helier. However, there is the suggestion that this increase

in sightings is simply because this is where humans are located, a typical floor with the scientific observation method of Citizen Science. This validity of is discussed later on. Therefore, certain rural regions could be other hotspots, but fewer hedgehogs are sighted due to a smaller human population.

The heatmaps illustrate the problem Jersey Hedgehogs seem to face. They hug the urbanised regions of the island, with very few occupying areas in the north due to the impacts previously discussed. Though, as is discussed later, this is an example of the limitation with citizen science projects. The other noticeable change over the last 15 years is that the populations are becoming increasingly disconnected, and connectivity between groups of individuals is reducing. Despite this, the hotspots are consistent over the three survey periods, and hedgehogs still thrive in the same regions of the island, especially in the south.

1.4 Jersey Hedgehog Preservation Group

The Jersey Hedgehog Preservation Group was set up in 1992 and rehabilitates and releases sick or injured individuals on the island back into the wild. They collaborate with Guernsey Hedgehog Rescue Centre and the British Hedgehog Preservation Society, all working towards the same goal. Ms Burdon, who runs the Jersey contingent, looks after approximately 300-400 hedgehogs yearly (Burdon, 1992). In addition to Hedgehog care, the Group promotes outreach as one of its main aims and objectives by increasing public awareness of the species in Jersey by conducting aforementioned public surveys, delivering talks to groups of all ages, media interviews and fundraising events.

The Group has three internal stages an injured hedgehog will pass through before being released into the wild. After admittance and assessment, the individual will stay in the ‘hospital’ section, receiving daily evaluation, support and relevant treatment for the required period. In extreme cases, the hedgehog is temporarily passed to the nearby Veterinary clinic for any medication it may need or, if wounds are especially severe, undergo an operation. Each individual’s weight is recorded daily to assess whether their mass increases. After the individual seems stable enough (health-wise) and reaches a target weight, usually 600/700g in the winter and 300/400g in the summer (when it is the breeding season), they are transferred to another section of the sanctuary where they have a pen with food, water and nest bag. Monitoring at this stage continues, with the quantity of food consumed noted and weight change recorded daily or every other day. As with transfer from stage one to stage two, once the individual re-

stabilises, hitting another ‘target figure’ and appears to ‘out-grow’ their pen, they undertake a soft release into one of the three outdoor pens, depending on their sex and age category – adult males have one, adult females another and juveniles the third. All three pens are weighed and recorded every third day, and once a target weight and length of stay have been reached, they are released back to the wild near the location of discovery.

1.5 Relevant Studies

Many hedgehog studies have been conducted in the UK and Europe due to their decline in population numbers. One study highly relevant to this project is the work of Morris (1997), who analysed the successfulness of rehabilitated hedgehogs that get released back into the wild. His principal aim was to compare the behaviour of wild hedgehogs and those released from care at the Preservation Group during the six weeks following liberation. In this study, 13 hedgehogs were released and monitored for the period stated. All individuals survived the following four weeks, with at least ten surviving a further two (Morris, 1997). From this study, it was observed that (i) there was an initial weight loss in most hedgehogs, but it stabilised for the majority of individuals after 2-3 weeks, (ii) all hedgehogs remained within a 400m radius of the release point for the first four weeks after release, (iii) despite supplementary food being provided for them, they did not make full use of it, sourcing other potential areas for replenishment and (iv) none were killed by a vehicle during the project (Morris, 1997). This study built upon work previously conducted in Suffolk (Morris *et al.,* 1993) and Devon (Morris & Warwick, 1994), where, in both cases, individuals were monitored for eight weeks after release. Following its conclusion, like the studies conducted in Suffolk and Devon, it was also observed that the weight, for most individuals, stabilised after the first three weeks following release, a consistent trend across multiple studies.

Morris (1998) collated the ideas of studies conducted in Suffolk, Devon and Jersey. The findings from this paper showed evidence of initial weight loss in individuals for the two weeks after release but had stabilised by the third (Morris, 1998). In addition, it was suggested that hedgehogs quickly adapted to new surroundings and did not attempt to return ‘home’; however, after approximately a week, a small percentage of hedgehogs undertook a long distance from the release site – this was evident in all three investigations (Morris *et al.,* 1993; Morris & Warwick, 1994; Morris, 1997). There was no observed aggressive behaviour between any of the released hedgehogs, and at times, frequent courtship was sighted. Furthermore, there was a single case of a successful pregnancy in a hedgehog release study (Sainsbury et al., 1996).

II. MATERIALS AND METHODS

2.1 Site Selection

Two sites were selected to assess the behavioural changes in hedgehogs on the UK channel island of Jersey, one representing an 'Urban' region and the other a more 'rural' area. In both cases, the hedgehogs will be tagged and released from a Garden within or neighbouring the selected area, this transmitter attaching method was agreed upon to minimise disturbance to the species. The Urban site was a small housing estate on the outskirts of St Helier, known locally as Samares, in the southwestern parish of St Clement. Despite having plenty of green spaces in and around the locality, this is the closest one would get to an Urban site without being in St Helier, the capital. Samares has all the usual amenities of a small town/village including a Primary School, a local church and playing fields. In and amongst all the flats and houses, there are few farms with fields on the owner's property – ideal spaces for sub-urban hedgehogs to roam forage in.

The rural site, in comparison, was the Royal Jersey Golf course, in the parish of Grouville, located on the east coast. Much like its urban counterpart, Grouville has a local Primary School, parish church and village pub. Although relatively similar in the landscape, the two sites are as diverse a variation in location change as possible on the island, when undertaking this method of attachment of the transmitters, as it is relatively sub-urban throughout, an issue discussed in the limitations of study section. The golf course is surrounded by properties in Grouville, many houses in Gorey village and the main coastal A-road. In addition, in line with this project's ethos of trying to cause as little disturbance as possible, if we did not attach the transmitter from a food source in a Garden, one would need to deploy traps in the desired location.

Figure 2a: Map of Jersey, UK Channel Islands, and the two study survey sites in Samares and Grouville, both in the southeastern corner of Jersey. Figures 2b(i) and 2b(ii) show sites 1 and 2 in more detail respectively.

Figure 2b(i): An in detail view of site 1 in Samares. Location of release site indicated in the garden of a volunteer for the Preservation Group. Locations of any significant land areas are illustrated in the legend.

Figure 2b(ii): In detail view of site 2 in Grouville. Location of release site indicated in the garden of a volunteer for the Preservation Group. Locations of any significant land areas are illustrated in the legend.

2.2 Transmitter attachment and release

Four hedgehogs (three Female and one Male) were radio-tracked for this study to obtain a good idea a hedgehog's home range in an urban and rural are of Jersey. Two of these, one female and one male, originated from Samares, St Clements and the two remaining females were located near the Royal Jersey Golf Course in Grouville. All four hedgehogs appeared healthy and mature due to their weight upon attachment of the transmitter and subsequent release (Table 1) and their shape and size. Following advice given to Ms Burdon and myself by Nigel Reeve, who has contributed to many hedgehog-related studies in the UK, the radio transmitters were attached to the spines in line with the shoulders on all individuals, using a locally sourced 5-minute 2-part epoxy glue. Once the transmitters were attached, each individual was returned to the feeding station, where they were found. All four radio transmitters had their unique radio frequency tuned to identify the location during surveys.

Figure 3: Hedgehog 3 just after attachment of the transmitter was performed; it was then placed back in the food station where they were found.

2.3 Weight

The weight of all four hedgehogs was recorded upon transmitter attachment and release. Assessing mass is one of the most common ways to evaluate a species' health, which is no different for hedgehogs. As previously stated, it is a crucial component in the transition of individuals through the Preservation Group, allowing Ms Burdon to know when to move a hedgehog on to the next stage of the process. Measuring the weight at the beginning of the tracking period allows one to assess whether any significant fluctuations occur during the survey. These substantial gains or losses could be explained once the individual's behaviour has been considered. Weight loss or gain might not just be simply down to behaviour; however, it could be due to the ecological landscape they occupy. As such, recording all individuals' weight before and after the survey period could also illustrate if an urban or rural setting impacts the healthiness of the species. Ideally, you weigh each hedgehog daily to assess changes on a smaller scale; however, due to the limited time and intent on reducing individual disturbance, it would only be conducted during transmitter attachment and detachment. Table 1 illustrates the weights of all four hedgehogs upon release.

Hog No.	Sex	W_0 (g)	Site	Radio Frequency (MHz)
1	**F**	**913**	**S**	**173.803**
2	**M**	**1015**	**S**	**173.946**
3	**F**	**832**	**G**	**173.324**
4	**F**	**792**	**G**	**173.345**

Table 1: The study individuals, Hedgehog number, gender, weight upon release and the site of release. S = Samares, G = Grouville. The radio frequency for each hedgehog was programmed into the receiver to establish locations.

2.4 Radiotracking

Due to the limited time, two surveys were conducted at each site to assess each individual's behaviour and observe their occupied areas. Each survey was conducted approximately between 9.30 p.m. and 1 a.m./1.30 a.m. with routes, potential nest sites, resource stations and vegetation types recorded - the time when the hedgehogs were first located varies. The starting point for each survey would be the release site, and scanning for a signal would commence. If a signal was not established, further scanning would occur within an approximate 1km distance to find each individual's location. Once the exact or approximate (via triangulation) location was determined, an alternation between the two individual bearings would occur.

The equipment used for this project was bought and ordered through NHBS Conservation Hub and was manufactured and dispatched to Jersey from the UK. During this project, the Lotek Biotracker VHF receiver was used to radio-track the individuals, a hand-held device with a shoulder strap for support. The transmitters were the Lotek VHF avian tags, model number PicoPip Ag379, specially designed for smaller species, such as hedgehogs. These tags are incredibly light and weigh only 0.44g in mass, adding a mere 0.06% to the average weight of a mature adult hedgehog. It is worth noting that upon advice from the Jersey Hedgehog Preservation group, no hedgehog was to have a transmitter attached to it if it was below 600g in weight due to the potential of the individual being infirm or too youthful to assess. The tags had a battery life of 42 days, which was more than enough for this project. The dimensions were 17mm x 8mm x 5mm and, as such, would not impact any behaviour, including potential courtship.

2.5 Jersey Hedgehog Preservation Group Surveys

Due to time restrictions, which are discussed in the limitations section, supplementing the study with analysis of stored data and examining previously conducted surveys was required. Jersey Hedgehog Preservation Group, as mentioned in the introduction, conducted three public surveys to assess population numbers and causes of death. The surveys were held in 2007, 2012 and 2023, beginning towards the start of the breeding season in April and finishing in December, when historically they should start to hibernate. In each case, the following parameters were recorded:

1. No. of hedgehog's alive
2. No. of hedgehog's dead
3. location of hedgehog
4. Grid reference (the island was grid referenced to help identify a more precise location)
5. Date
6. Previous sightings

A Comparative analysis of these surveys was conducted and included in this year's newsletter. Using the 3D maps function in Microsoft Excel, heat distribution maps were created to assess the coverage of the hedgehog population in Jersey.

Further to this, as stated the Surveys were split into a grid system to assess the number of sightings per grid reference. A comparison was conducted between the two cells most associated with the sites selected for this project (Samares [N12] and Grouville [Q10]), with reasons behind these figures discussed below.

2.6 Jersey Biodiversity Centre Data

In addition to the data provided by the Preservation Group, the Jersey Biodiversity Centre has supplied specific data to the target location sites in Samares and St Helier, and the Grouville and Gorey area. This data provided a more conclusive look at the occupation levels in the selected locations analysed in this project. Much like the data provided by the Preservation group, this dataset had many of the same parameters; however, in addition to this, these hedgehogs were all admissions to the Preservation group for treatment, confirmed by Ms Burdon when providing her with a location, date of entry and ID number and as such, the weight were recorded and included in this dataset to gauge when release back to the wild was

appropriate. This data was visualised to compare coverage and occupancy levels, and the individual weights were analysed.

2.7 Statistical Analysis

A Shapiro test was conducted to assess whether the weight data was normally distributed or not to establish whether an unpaired t-test (parametric) or Mann-Whitney U (Non-parametric) test would be computed.

III. RESULTS

3.1 Tag Attachment

Three radio transmitters successfully remained attached for the entire survey period (Hedgehog no. 1 [Samares], 3 and 4 [both Grouville]. However, one did detach itself and was found in a nest in a garden during the first survey (hedgehog number 2 [Samares]); the location where it was retrieved is illustrated in Figure 3a, showing, at the very minimum, how far this individual travelled and the regions it occupied, compared to the release site location. Due to 75% of the transmitters staying attached for the survey, it is likely it was securely fixed and simply hapless it became detached. In addition, when removing the remaining three transmitters, there was no sign that they would fall off shortly after the survey period; they were all still very secure. Despite this unfortunate development, there was no reason to believe that the hedgehog had deceased either between the day of release or after the discovery of the transmitter and, therefore, presumed still alive.

3.2 Landscape Utilisation, travel and nest sites

During the radio-tracking period, the hedgehogs utilised and navigated a wide range of different landscapes. In Samaras, the urban site, there was a greater variety of topography they travelled across and through to get to their desired locations; these included farmer's fields, footpaths, private gardens, driveways, roads and hedgerows. Hedgehog number 1 travelled a fair distance to access areas where they knew food and water would be, usually in residential gardens, travelling a few hundred metres from an approximate nesting location. In addition, Hedgehog number 1 appeared to be on more of a regular body clock than Hedgehog number 3 and 4 as it returned to the release site at precisely the same time during survey number one as when the transmitter was attached a day or two earlier. The exact location Hedgehog 1 nests in was not

obtained during the survey period. However, an approximate region is presented in Figure 3a – this area was highlighted due to the direction of travel in both surveys conducted.

Unfortunately, Hedgehog 2's transmitter was found two days after attachment in a garden off the St Clement's coast road, 371m away from the release site, suggesting this individual covers a significant distance during an evening commute. Hedgehog 2 was identified as a male and, therefore, could indicate the reason behind a substantial distance coverage, as they are notorious for travelling more than females. The transmitter was found in the nest that Hedgehog 2 made use of, and a wild hedgehog was nesting there upon retrieval; as such, there is potential that Hedgehog 2 had interaction with it at some point.

Comparatively, Hedgehog 3 tended to stick to similar terrains during this survey period, whereas Hedgehog 4 was more erratic. Over the two surveys, Hedgehog 3 passed through the same gardens and appeared to nest in a similar location daily. A nest was established upon detachment of the transmitter, a residential garden on the opposite side of the coast road, amongst grass cuttings and broken tree branches. However, Hedgehog 3 did not seek refuge or resources at the release site once during either of the two surveys, suggesting it was a coincidence they visited on the night the transmitters were attached.

Hedgehog 4, on the other hand, covered a much further distance than Hedgehog 3 during both survey periods. In addition, unlike Hedgehog 1 in Samares, which appears capable of traversing across many different landscape types, exploring multiple routes during the survey period. This individual covered the most ground of all three and used the release site resource station during survey 2 in Grouville. A nest site location was not established for Hedgehog 4, due to the differing locations first sighted during both surveys.

3.3 Weight changes

There were various weight changes among the three hedgehogs surveyed for this project. As Table 2 illustrates, Hedgehog 1 and 3 gained weight over the survey period, whereas Hedgehog 4 lost weight. A debate behind these weight changes is considered in the discussion.

Hog No.	Sex	W_0 (g)	W_1 (g)	ΔW (g)	Site
1	**F**	**913**	**965**	**+52**	**S**
2	**M**	**1015**	**N/a**	**N/a**	**S**
3	**F**	**832**	**903**	**+71**	**G**
4	**F**	**792**	**783**	**-9**	**G**

Table 2: Weight changes of the survey individual at transmitter attachment and detachment. W_0 = initial weight, W_1= final weight, **ΔW** = change in weight

3.4 Route Maps

3.4.1 Samares

Figure 4a: Survey 1 route maps of hedgehog 1 (and hedgehog 2) in Samares with legend illustrating tracked routes and important landmarks.

Figure 4b: Survey 2 route maps of hedgehog 1 in Samares with legend illustrating tracked routes and important landmarks.

3.4.2 Grouville

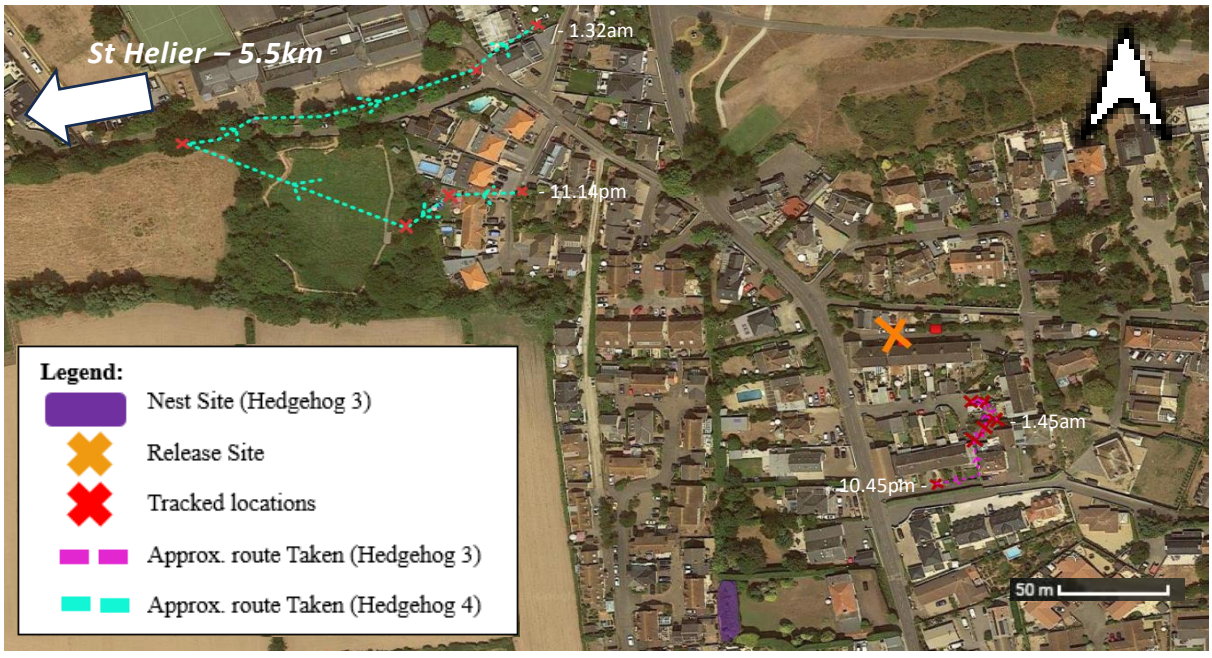


Figure 5a: Survey route 1 maps of hedgehogs 3 and 4 in Grouville, with legend illustrating tracked routes and important landmarks.

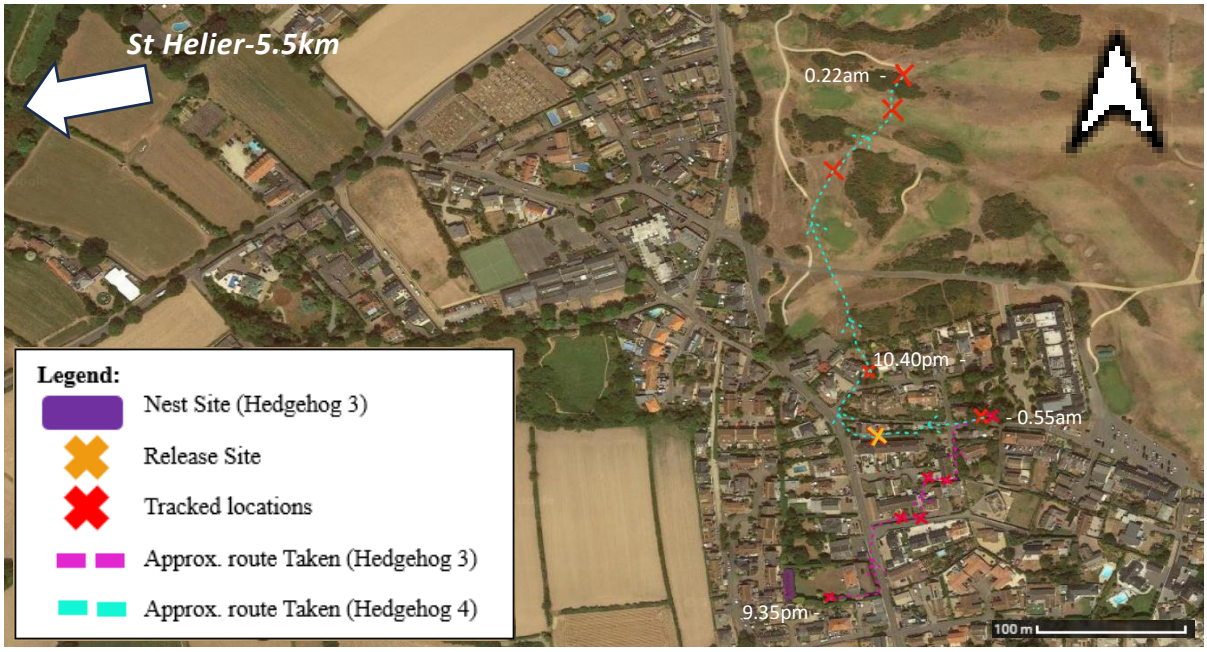


Figure 5b: Survey 2 route maps of hedgehogs 3 and 4 in Grouville, with legend illustrating tracked routes and important landmarks.

3.5 Movements & Final locations

Hog No.	Site	Distance travelled (m) [S1*]	Min-max distance from release site (m) [S1*]	Distance travelled (m) [S2*]	Min-max distance from release site (m) [S2*]	Distance travelled (m) [S1 + S2]	Min-max distance from release site (m) [S1 +S2*]
1	S	433	0-178	332.6	294-329	765.6	0-329
2	S	-	-	-	-	-	-
3	G	79	38-53	220.7	53-139	299.7	38-139
4	G	311	165-302	514.9	0-313	825.9	0-313

* S1 and S2 denote survey 1 and survey 2 respectively.

Table 3: The distance travelled during survey 1 and survey 2, individual and combined. The Minimum and maximum distances away from the release site.

Hog No.	Sex	Site	Transmitter fallen off/Unattached	Nights/days after release	Distance from release site (m)	Direction away from release site
1	F	S	U	8	339.40	E
2	M	S	F	5	372.96	NW
3	F	G	U	7	140.32	SW
4	F	G	U	7	313.55	N

Table 4: Last known location of each hedgehog, when removal of the transmitter was performed, and the distance this was away from release site.

No detachment of tags occurred at either release site, as is shown in Table 3.

3.6 Vegetation use and nesting

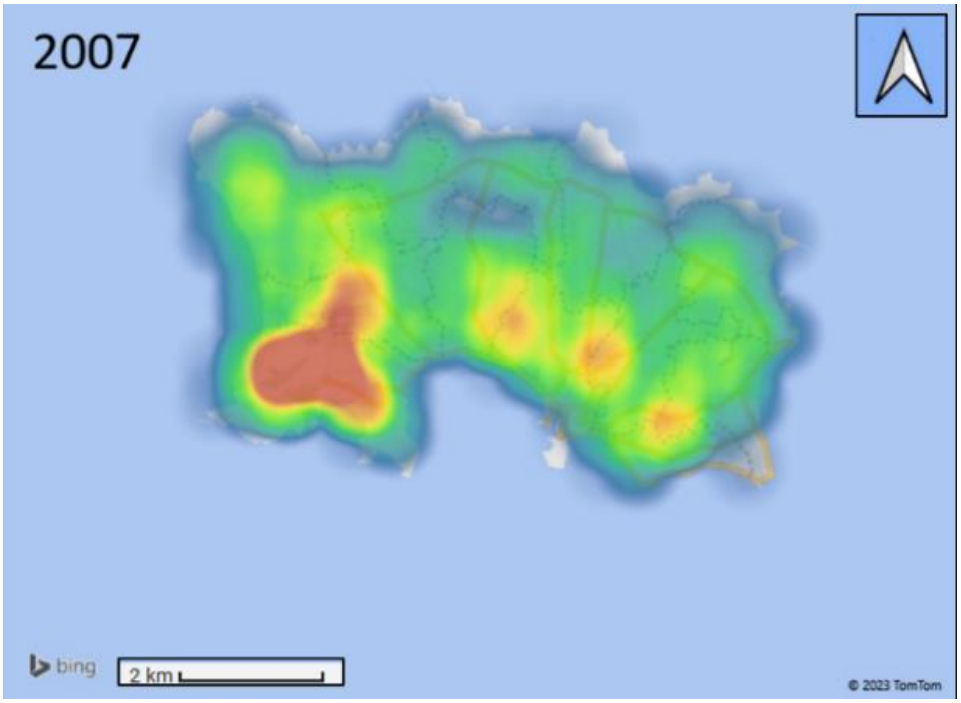
Confirmed nest sites were found in private gardens; one inside old grass cuttings/broken tree branches and another in black garden mesh filled with hay by the property owner. Approximate nest site areas included farmyards, the nearby fields, hedgerows and shelter along tree lines. In the cases of Hedgehogs 1 and 3, it appeared that they were nesting in the same places before both surveys were conducted; this information was unattained for Hedgehog 4, although highly likely was in similar vegetation types stated above. However, it did appear that Hedgehog 4 was using multiple nests due to the different directions it was moving in at the beginning of both surveys.

3.7 Wild hedgehog interactions

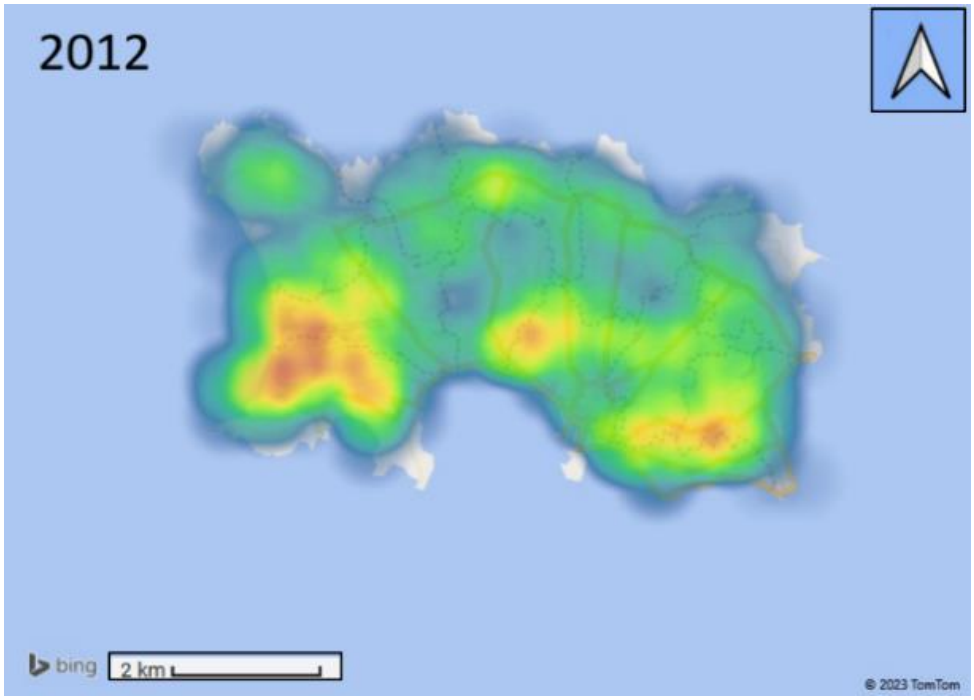
Minimal interaction between the study hedgehogs and other wild hedgehogs was witnessed during the timeframe of this project. However, during the first survey in Samares, Hedgehog 1 was seen interacting with a wild hedgehog when it arrived at the release site that evening. Hedgehog 1 was possibly acting territorially towards this other hedgehog, perhaps trying to stamp their authority and usher it away from the feeding station. Otherwise, no interactions with wild hedgehogs were witnessed.

3.8 Jersey Hedgehog Preservation Group Surveys

i)



ii)



iii)

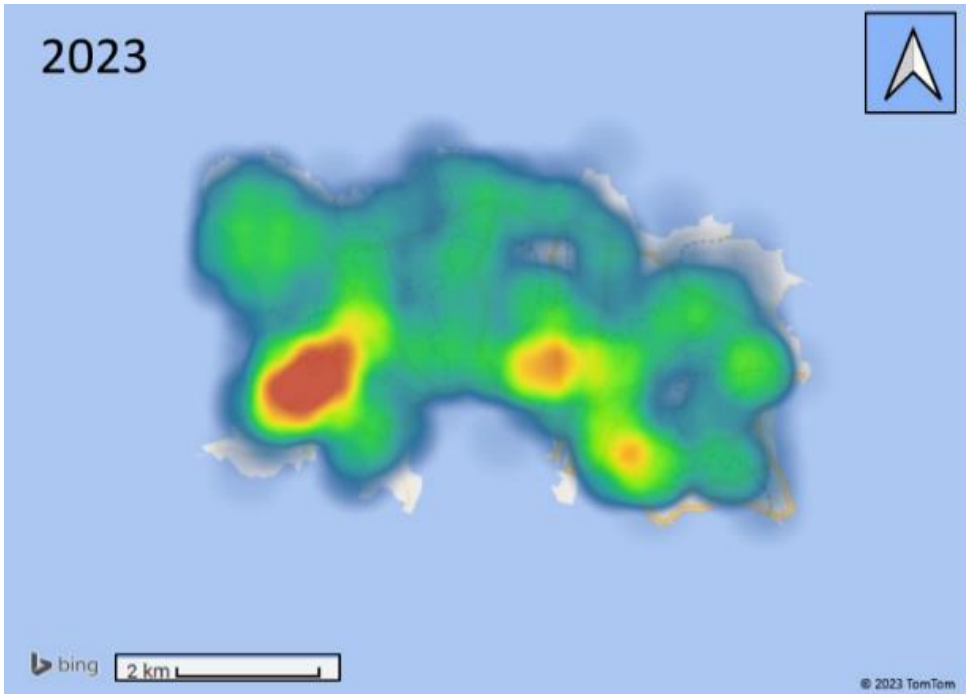


Figure 6: Hedgehog population heatmaps in Jersey following public surveys in i) 2007, ii) 2012 and iii) 2023 [Data provided by Jersey Hedgehog Preservation Group]i)

	Total Sightings (Including deaths and ones that have since died post care)						Deaths				
Year	**Roads**	**Fields**	**Garden**	**Other/Unclassified**	**Total**	**Total alive**	**Roads**	**Field**	**Garden**	**Total**	**% Dead**
2007	1077	226	1015	10	2318	1255	277	77	709	1063	46%
2012	506	31	546	36	1119	676	403	12	28	443	40%
2023	439	182	875	181	1677	1518	128	8	23	159	10%

Table 5a: Results from the three surveys conducted by the Jersey Hedgehog Preservation Group in 2007, 2012 and 2023

	Samares (N12)			Grouville (Q10)		
	2007	**2012**	**2023**	**2007**	**2012**	**2023**
Sightings	11	5	1	16	11	2
Alive	8	2	1	8	1	2
Dead	3	3	0	8	10	0
%Alive	73	40	100	50	9	100
% Dead	27	60	0	50	91	0

Table 5b: Comparison between the two selected sites results from the Preservation Group Survey.

3.9 Jersey Biodiversity Centre data

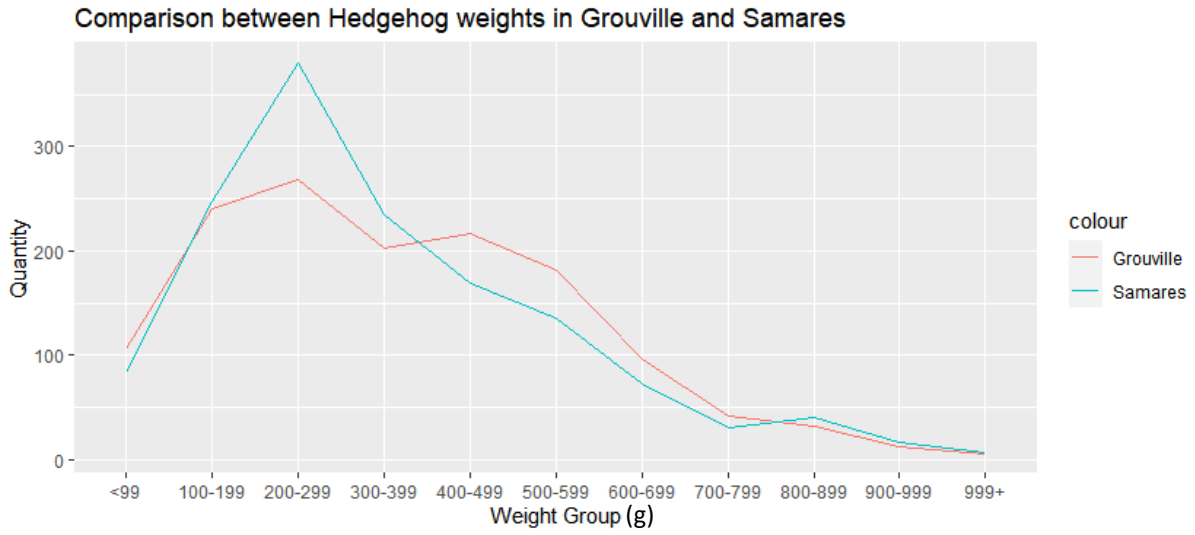


Figure 7: Graphical representation of the weight groups of hedgehog admissions to the Preservation group from Samares and Grouville.

Figure 4 illustrates that Samares hedgehogs appear to have less hedgehogs in most weight groups than the Grouville hedgehogs.

3.10 Shapiro Wilk and Mann Whitney U tests

To test whether there was a significant difference between the weights of the Hedgehogs located in the Grouville region and the Samares area, one must firstly test to see whether the data is normally distributed. In the case of the data provided by the Jersey Biodiversity Centre, both Grouville (W = 0.96508, *p-value* = $<2.2\text{x}10^{-16}$) and Samares' (W = 0.93092, *p-value* = $2.2\text{x}10^{-16}$) weight data was not normally distributed, due to both *p-values* being less than the

alpha threshold value of 0.05, and therefore non-parametric test must be computed to test for significant differences.

To assess whether the weights of the two areas had statistically different medians, the Mann-Whitney U test, a non-parametric version of the two-tailed t-test, was conducted. Firstly, the data was visualised by producing boxplots with the 'ggboxplot' function in R (Figure 5).

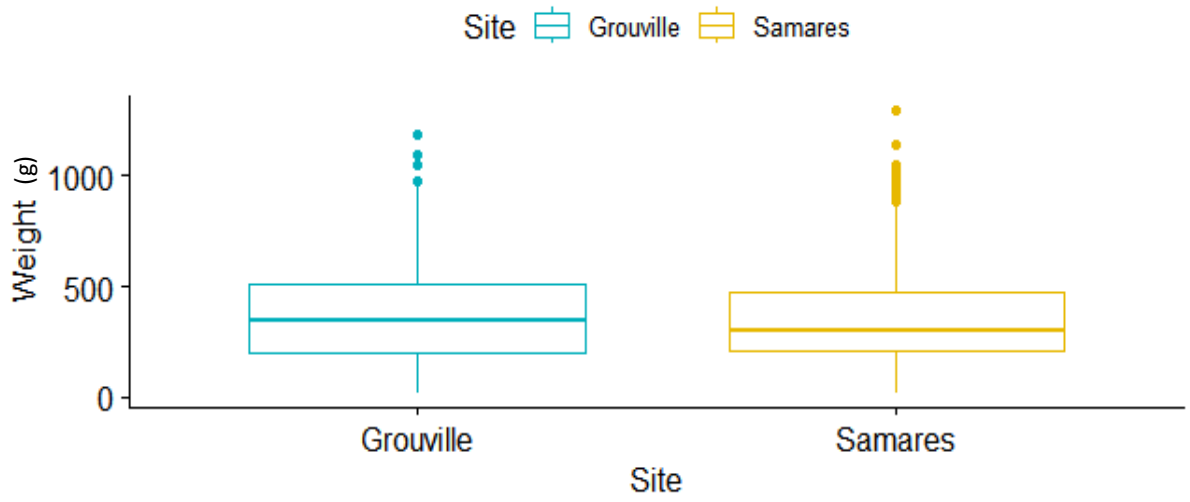


Figure 8: Boxplots showing the weight comparisons of Hedgehogs in the Grouville and Samares areas.

The Mann-Whitney U test was conducted using the 'wilcox.test' function in R. When testing to see if the medians of the two groups were equal, it was concluded that the Grouville-based hedgehog's median weight is significantly different to the Samares-based hedgehog's median weight (W = 1047467, *p-value* = 0.01474), agreeing with the boxplots in figure 5. Furthermore, an additional test illustrated that the Grouville hedgehog's weight is significantly greater than the individuals in Samares, which it was as well (W = 1047467, *p-value* = 0.007371). These results make sense as the median weight for Grouville and Samares are M_G = 344g and M_S = 298g respectively.

IV. DISCUSSION

The results from this study illustrate that there is reason for concern over the hedgehog population in Jersey, mirroring the conclusions made of other researchers studying the European hedgehog, with survey results showing an overall population decline. Over the 16 years between the first and last surveys, there has been a 28% reduction in total individual sightings (Table 5a). However, despite this, there is a marked reduction in the number of sighted deaths in the 2023 survey compared to the previous two. There has also been a swing in the vegetation type hedgehogs found in, with a higher percentage of individuals spotted in private gardens in urbanised regions, 52% in 2023 compared to the 44% figure in 2007.

The heatmaps in Figure 3 show a continued preference towards urbanised regions, with 'hotspots', or more people seeing individuals, in the capital city of St Helier and in St Brelades, the next most populous town in the southwest corner of the island. The Jersey population is also becoming increasingly fragmented, with less continual coverage seen in 2012 and even more so in 2023, with fewer individuals occupying regions on the north coast. There also appears to be a decreasing number of 'hotspots' with every successive survey, and the area (km^2) of occupancy of these hotspots is diminishing likewise. In 2007, we can see the primary hotspot in St Brelades and three minor hotspots towards the island's eastern side in St Helier and the surrounding suburbs. Whereas, in 2023, the area of the St Brelades population appears to decrease quite significantly, and there are now only two smaller hotspots near the capital – a worrying sign if these trends continue.

The radio-tracking surveys also provided some intriguing results, and with a more extended period of assessment to establish individual movements, trends would likely be observed. Despite being somewhat similar in landscape, patterns did arise from the behaviour of the urban hedgehog and its rural counterparts. During the first 'urban' survey, Hedgehog 1, which occupied regions of Samares, was very direct with its movements and knew how to navigate the housing estate to travel to its desired location of the release site, where food was deployed. In addition, it was on a strict time frame as it arrived at the release site at approximately the same time the transmitter was attached, a couple of days earlier – potentially suggesting urban hedgehog's behaviour is more consistent due to limited resources, such as natural food in arthropods or molluscs, and restrictions in where they can navigate. Survey 2 in Samares also highlighted a potential problem urbanised hedgehogs face. During most of the evening,

Hedgehog 1 roamed predominantly in the same field, possibly trying to break through the field boundaries with little success – this was surprising as the expectation was that it would follow the same route to the release site, as it had during survey 1. Habitat fragmentation is a common theme amongst researchers when discussing factors that negatively affect populations of hedgehogs, caused by barriers (Hof & Bright, 2009; Braaker *et al.,* 2017), including walls, fences or roads that individuals cannot pass through (Huijser & Bergers, 2000; Pettett *et al.,* 2017; Rondinini & Doncaster, 2002; Braaker *et al.,* 2014), reducing interconnectivity and resource accessibility.

Figure 9: Hedgehog 1 on a side road outside some houses during Survey 1 in Samares.

The rural surveys also surfaced some potential issues, possibly suggesting why hedgehogs favour green spaces in urban regions rather than more remote areas. There was a greater sense of linear movement with Hedgehog 3 and 4, compared to Hedgehog 1. There was little retracing of steps, rather continued forward movement, potentially due to fewer obstructions. This perpetual movement could be due to their desire to locate wild food sources or less high-quality shelter spots and/or nesting areas. Hedgehog 4 illustrated this with very different movements and areas they were roaming in during Survey 1 and 2. Despite Hedgehog 3 utilising the same areas, which could be down to random chance, a repeat of this project and an extended survey period with a higher sample size would likely remove this bias and eradicate anomalous movements. The constant excessive need to be continually on the move, visible in Hedgehog

4's movements, could be due to a search for a higher quality habitat or more natural food sources. Urbanised regions are said to provide hedgehogs with a greater variety of opportunities including a higher habitat quality (Zingg, 1994; Egli *et al.,* 2004), more anthropogenically deployed food available (Doncaster *et al.,* 1990; Contesse, P. *et al.*, 2004), more substantial vegetation structure to nest in (Baker & Harris, 2007) and climatic conditions more suitable for the species (Pickett *et al.,* 2001), possibly explaining hedgehogs 4's behaviour.

Figure 10: Hedgehog 4 emerging from the overgrowth during Survey 1 in Grouville**.**

Citizen science is a growing method to survey wildlife, and it is no less suitable to assess hedgehog behaviour and the areas they occupy. With this technique implemented, access to semi-privately or privately owned lands allows data to be obtained, which would otherwise not be possible (Taucher *et al.,* 2020). This potential hurdle is made slightly easier in Jersey due to the 'No Trespass Law', but it would still be uncourteous to roam areas of personal property during hours of the evening, and it would be nearly impossible to ask all homeowners to access their land. This method was exploited to gather the data held at the Jersey Biodiversity Centre, given to them by the Preservation Group. Figure 4 shows that Grouville hedgehogs are, on average, heavier than those individuals in Samares, suggesting that rural hedgehogs find gaining and sustaining weight easier. This weight difference could be because more natural food sources are available to them, or a greater distance must be travelled to locate replenishment, possibly deployed by humans in urban regions. These results concurred with

the boxplots in Figure 5, which illustrated that Grouville hedgehogs have a slightly higher average weight than Samares.

Furthermore, this result proved statistically significant when performing a Mann-Whitney U test to see if the two sample means were equal; instead, as previously mentioned, the rural hedgehogs have a higher average weight. There needs to be more written in the literature about the weight differences between urban and rural hedgehogs to assess levels of healthiness, of which very little is published. Instead, the focus is mainly on the densities of hedgehog populations in these differing vegetation-type regions. Naturally, rural areas should still provide hedgehogs with all the necessary amenities to survive and thrive; however, modifying the land in these regions forces them to convert to a more urbanised lifestyle, possibly considered an ecological trap. Despite this, some studies identify built-up areas as important habitats of refuge for the species (Hof & Bright, 2009; Huijser, 1999).

4.1 Urbanisation and the effect this has had on hedgehogs

As has already been touched upon, there has been a considerable shift towards a more urbanised lifestyle for the European hedgehog in recent decades. The question, however, whether this transition acts as an ecological opportunity is still being determined. Urban areas provide hedgehogs with a higher standard and greater variety of habitats than rural regions, rendering a unique ecosystem (Taucher *et al.,* 2020). This exploitation of resources was epitomised by Hedgehog 3 in this radio-tracking survey, which had found a high-quality, well-protected nest amongst broken tree branches and other vegetation in a private garden. Again, these areas provide hedgehogs with more anthropogenic food resources and fewer natural predators (Fernández-Juricic & Tellería, 2000; Reijnen *et al.,* 1997; Dowding, C.V. *et al.*, 2010; Werner, P., 2011) – although the latter does not affect hedgehogs in Jersey as there are no known predators, i.e. badgers or foxes, present on the island.

The fragmented nature of hedgehogs in urban regions can also create problems for the species. 16,750km^2 of UK land is categorised as built-up, and over half is used or developed for agricultural purposes (UK National Ecosystem Assessment, 2011). Observed biodiversity losses in rural and urban areas in the UK are due to an increase in intensively managed farmlands and expansion of built-up regions (Stoate *et al.,* 2001; Foley *et al.,* 2005; Macdonald & Feber, 2015). The destruction of hedgerows and grass verges, often called dispersal structures for animals, including hedgehogs, threatens individuals and causes populations to

become isolated (Taucher *et al.,* 2020). In Jersey, the Branchage event occurs twice yearly for three weeks in June and September, causing several hedgehog injuries and significantly increasing admissions to the Jersey Preservation Group. Other barriers can cause issues for individuals accessing areas of refuge or replenishment – a problem Hedgehog 1 might have encountered during survey 2 in Samares. In addition, the loss of habitat during garden maintenance can lead to a loss of natural nesting opportunities for hedgehogs (Wilson, 2018), shelter or spots for hiding. Private gardens also provide landscape challenges to hedgehogs where they might find themselves trapped, falling into garden hazards, such as Swimming pools with no ramp for them to climb out of, football nets that are not brought in overnight or holes in the ground that they are unable to climb out of (Taucher *et al.,* 2020). However, potential hazards aren't solely garden-related and extend to public spaces. The preservation group had an admission in the summer of 2023 that got stuck under a metal railing surrounding FB Fields in St. Clements, with insufficient margin between the upright metal posts for hedgehogs to travel under, causing nasty injuries that could have been prevented. Of course, security in public places like this, where sport is played weekly, is paramount; however, if some consideration for nature could be taken before erecting such structures, a reduction in wounded animals would follow. Fragmented populations can also lead to decreased reproducibility, lower fecundity rates and dwindling species numbers. Inter-connected populations have a far greater chance of successful reproduction due to many more opportunities to find a breeding partner rather than just within their small-scale community. Hedgehog highways significantly help with this issue, allowing hedgehogs to safely travel through built-up areas, connecting them to other individuals.

Another concern facing hedgehogs in urbanised regions is the amount and quality of food present or whether they can locate it. Many papers state that this shift towards a more urbanised way of living for hedgehogs unlocks the opportunity to find anthropogenically deployed cat or dog food, which would otherwise not be present in a rural setting; as such, citizen science can help to assess how much food is being deployed in a local area. As we know from the radio-tracking surveys conducted for this project, this food distribution is ongoing in Jersey, with many volunteers at the preservation group and other members of the public placing food out into their gardens and, more often than not, it is consumed overnight. As such, from a particular perspective, this is a positive result in that we are bolstering hedgehog survival; however, you could also view it as an alteration of their natural behaviour. Many arthropods and molluscs, which compose a large proportion of a hedgehog's raw diet, are vast in gardens, another reason

hedgehogs congregate in private plots, parks or estates. Again, more evidence suggests an urbanised lifestyle might be more suitable for the species. Studies have shown that hedgehog abundance is correlated with the presence of earthworms in grass fields, amenity grasslands and garden lawns in rural villages that contain the highest densities of earthworms in comparison to areas used for agricultural purposes (Doncaster 1994, Micol et al., 1994; Morris, 1985; Hubert *et al.*, 2011) - another reason to suggest switching to an urban lifestyle benefits hedgehogs.

Nevertheless, Climate change might also have a big part to play in this successful transition to a new landscape for hedgehogs, and it isn't just the direct effects of this global phenomenon that affect their distribution, for example. Hedgehogs might also indirectly suffer from the impact of climate change, with a conversion in the natural occupancy areas of their standard diet. Invertebrates such as worms, slugs and beetles will change their environment with these increasing global temperatures, indicating hedgehogs will have to alter theirs likewise. In addition, an ever-changing landscape in towns and cities, with the continued erection of new buildings, was created to support jobs and bolster further living opportunities. Consequently, green spaces will diminish, fewer invertebrates will be present and natural food sources for hedgehogs will reduce. This food depletion was observed in Zurich and cited as contributing to the decline in hedgehog numbers in the city, explaining a 'spatially patchy pattern' (Taucher *et al.,*2020). If this is the case, the reliance on garden owners providing artificial food sources to hedgehogs is essential. The deployment of food in gardens does increase sightings and activity levels during the winter months when individuals should be hibernating (Gazzard & Baker, 2020). This topic is of massive concern in St Helier in Jersey, as plenty of new flats are being built in the city, creating a concrete jungle for hedgehogs to survive in.

Another reason to convert to urban areas for hedgehogs is to reduce the chance of co-existence with species that will outcompete them regarding food. Albeit not entirely, invertebrates comprise part of a badger's and fox's diet. Therefore, with this reduction in the presence of these predatory species, theoretically, more nourishment should be available to hedgehogs. As stated above, this is not the case in Jersey as there are no badgers or foxes on the island and, therefore, not a reason for this contingent to move to urbanised regions.

Finally, another trap hedgehogs can fall into when occupying green spaces in urbanised regions, such as gardens, is the consumption of poisonous pesticides. Due to their insectivore status,

individuals are susceptible to such chemicals and poison themselves when ingested. Opportunistic feeders (Wroot, 1984; Yalden, 1976) might encounter pesticides directly by consuming poisonous bait or indirectly when digesting prey that has ingested such chemicals. A reason why sticking to rural regions is a benefit to the species.

4.2 The issues rural hedgehogs face and why they're converting to urbanised regions

As we know, hedgehog numbers have been dwindling for some time, but it was recently observed in the UK that these declines are more severe in rural areas than in more urban regions (JNCC, 2010; Aebischer *et al.,* 2011), and this is as a result of multiple reasons.

Predation is one reason behind this shift of converting to more built-up areas to roam in. Despite domestic dogs and cats causing some issues to the species when foraging in private gardens, they can only predate on injured or juvenile hedgehogs (Reeve & Huijser, 1999); as such, a good proportion of the population should be safe. The avoidance of natural predators, badgers and foxes, is a part of the hedgehog's innate instincts to prevent direct predation and being out-competed for food sources (Taucher *et al.,* 2020), with the former the only Fauna capable of uncurling a hedgehog from its default defensive position (Neal, 1986) and cause severe harm or potentially kill. As aforementioned, this is not an issue for Jersey-based hedgehogs, as foxes or badgers are neither native nor invasive to the island.

Further rationale behind this urban-adapting behaviour is due to the deterioration of their habitat in rural areas. Hedgehogs occupy a wide range of habitat types (Hubert *et al.,* 2011), but the majority prefer the edge of woodlands, hedgerows, and, more recently, the borders of gardens. Forestry regions and agricultural lands contain minimal population numbers due to a lack of insects to prey on, the latter due to the work that occurs here all year around. Habitat loss is one of the key drivers behind recent hedgehog declines. The removal of hedgerows, coupled with a massive increase in newly built properties, significantly reduces a 'rural' landscape's carrying capacity and, as such, hedgehogs will find it challenging to locate nesting spots during the summer months and places to hibernate during the winter (Warwickshire Wildlife Trust, 2023). Much of Jersey's new building work is occurring in the main towns and capital city of St. Helier, and therefore, rural hedgehogs on the island should not be affected too much. However, the destruction of hedgerows during Branchage will do the most damage to this population of hedgehogs in the Channel Islands. Nesting sites and hibernation spots

could very well be destroyed during the mass strimming and cutting back of vegetation that occurs twice a year. This annual event must be addressed and altered to prevent the further dwindling hedgehog population count in Jersey.

Finally, large-scale pesticide use by farmers in arable fields also contributes to the declining numbers of rural hedgehogs, reducing the number of invertebrates present for them to feed on. Similarly to what is said about gardens, hedgehogs are directly and indirectly affected by deploying such chemicals, consuming them or ingesting invertebrates that have themselves, respectively. This issue is very much present in Jersey due to the amount of arable land, especially as you travel north. Therefore, it is not coincident that hedgehog abundance is lower in the north than in the south of the island. Establishments in Jersey, such as the Jersey Royals farm and the Jersey Dairy, are expected to use pesticides to prevent invertebrates from eating produce. In the case of the Jersey Royals, plastic sheeting is placed over the potatoes to protect them from being eaten by any Fauna. However, this also restricts hedgehogs from accessing the invertebrates in the soil in these areas. As such, agricultural land is fast becoming an inappropriate place for hedgehogs to live, feed and roam in, and their only option is to revert to more urbanised areas.

4.3 Future Work

There is still massive scope for research and work surrounding the European Hedgehog *Erinaceus europaeus,* and not just in Jersey. Many studies have been produced in 2023 to assess behaviour distribution changes and monitor population declines. Further contemporary radio-tracking studies are required continentally to understand how hedgehogs continue to struggle. An increase in radio-tracking studies using albeit highly lavish GPS trackers should be conducted to assess their movements around the clock, establishing areas they roam and forage in, in addition to all nesting sites. Although more than adequate, non-GPS trackers have data-deficient limitations, and you need to be tracking 24 hours a day to avoid periods of uncertainty as to where they roam.

Increased efforts are required worldwide and in places like Jersey to continue these efforts to increase hedgehog populations again. Further experimentation to assess small changes in all industries and everyday life which can be made to obtain this result, avoiding individual injuries and demises, is required. The wounds suffered (or demises inflicted) from the

strimming during the Branchage event, cars driving too fast or becoming trapped between two metal poles of fences bordering the sports field are examples of the admissions to the Preservation Group that can be easily circumvented.

There is potential for another MSc student to extend and build upon the research and assessment of Jersey's hedgehog population conducted for this study. An extended radio-tracking period and a higher initial sample size of hedgehogs tracked could provide more thorough, consistent and worthwhile results than the outputs obtained for the practical section of this project. Albeit peripheral, the outcomes acquired in this study illustrate that there is some science behind hedgehog populations in Jersey, and a sequential radio-tracking project would be beneficial and high-yielding.

V. Study limitations and improvements

The first significant limitation of this study was the time given to conduct a radio-tracking survey due to the delays in the delivery of the equipment. This restriction is the reason why the project was supplemented with historical data collected that is stored at both the Preservation Group and the Jersey Biodiversity Centre, supporting patterns shown in the route maps from this study's surveys, which illustrated enough evidence to imply further trends would be found if they were conducted over a more extended period.

Due to the condensed period to observe movements, a smaller sample size was used to reduce potential errors or unforeseen issues that might occur. A larger sample size would not only yield more data but also further highlight any significant contrasts in the behaviour of urban and rural hedgehogs. The original idea was to radio-track four or five hedgehogs over two months, four weeks focusing on one survey site and the latter on the other. This re-design of the project would provide are greater quantity and more robust data.

Increasing the number of sites surveyed would also herald better, more reliable data. Four survey sites were suggested, rural and urban, to compare differences between similar landscape types and not just between the contrasting topography. It was recommended, although not executed due to the time pressure, that assessing three or four hedgehogs at four different sites, two rural and two urban, would create a good study. This solution would be highly feasible in

Jersey as there are ample rural regions, especially when you travel further north, and there are two ideal urban areas in St. Brelades and St. Helier (and its outskirts - which was chosen for this study).

Furthermore, citizen science is a powerful tool, especially when observing small mammals such as hedgehogs, which access areas that are tricky to observe and monitor, like private gardens. However, there is a considerable bias towards urban-inhabiting hedgehog observations as more people are present in these urban regions. A large community of hedgehogs could be thriving in northern areas of the island, but this information will be known if sufficient research is conducted. Still, because most of the human population resides on the southern coastline, individuals are far more likely not to be spotted in these northern territories.

VI. Conclusions and reflections

This study presents a suite of results assessing the status of hedgehog populations in Jersey, with a combination of data collected specifically for this project and supplementing it with previously gathered data. It has shown considerable concern for urban and rural dwellers for differing reasons. A shift in Climatic condition and human intervention in Jersey have forced the species to convert to a more urban lifestyle, presenting a fresh set of new challenges to hedgehogs. However, statistical analysis shows that they still thrive better in rural regions, with these individuals having a higher average weight than their urban counterparts. This result could be due to a higher density of natural food available to them; less distance travelled is required to find food, water or places to nest, or fewer boundaries to overcome when locating areas for refuge, with a statistically significant result obtained.

This study should only be the start of contemporary research on hedgehogs in Jersey and the Channel Islands as a collective. The results prove that there is a science to the methods presented, and continued monitoring is necessary. If some minor changes to people's everyday lifestyle were applied, hedgehogs could prosper again. The decline in hedgehog population numbers already appears to be slowing down as shown by the public surveys conducted. In addition, fewer deaths were reported in 2023 than in the previous surveys in 2007 and 2012. The work the Preservation Group do is astonishing, and the success stories that come from it are irreplaceable. If the Group had not started 30 years ago, the hedgehog would likely have been extirpated on the island. However, more concerted efforts need to be placed on preventing

hedgehog injuries and demises in the wild, and the sanctuary should act as a last resort rather than a continual bolstering of the population – something the members of the public should embrace.

In terms of an ideal location for the modern hedgehog, a mixture of rural and urban landscapes is the solution. Interchanging between high-quality habitats and nesting sites, in addition to anthropogenically deployed food sources, coupled with the freedom to roam in rural areas, locating natural sources of food and avoiding potential hazards which we perpetually are present in these built-up areas, might be the solution. Village-styled locations could be the answer, with local farmers' fields nearby with excessive space to roam and access private gardens where food has been deployed is the best option for the species currently.

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