RELEASED, REHABILITATED HEDGEHOGS: A FOLLOW-UP STUDY IN JERSEY

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Thirteen overwintered juvenile hedgehogs (six male, seven female) were released in an area of farm land and gardens on Jersey, Channel Islands. Six (three of each sex) were originally from the same area, the rest came from other parts of the island. They were radio-tracked and monitored regularly for 6 weeks to investigate survival and especially whether 'site-native' animals and those from elsewhere differed in respect of their propensity to disperse widely following release. All animals survived at least 4 weeks and 10 were known to be alive after 6 weeks. The fate of the others is unknown, but there is no reason to believe that any of them suffered an early death.

Male hedgehogs used new nests more frequently than females. All remained within 400m of the release point for at least a month, some were still within 200m 6 weeks post-release. Five hedgehogs dispersed, travelling at least 400m from the release point. Four of these were males, including one recaptured 5.2km away. Dispersal seemed to be more related to sex than origin. All animals lost weight initially, but most stabilized after 2–3 weeks; proportionately more weight was lost by larger animals. None was seen to use supplementary food put out for them, despite weight losses, and no aggressive interactions with wild conspecifics were noted. Despite all the animals being naïve juveniles, with little or no previous experience of life in the wild, none were killed by road traffic. Positive conclusions from previous studies concerning the success and welfare implications of releasing hedgehogs after care in captivity are confirmed.

Keywords: *animal welfare, hedgehog, reintroduction*

Introduction

Each year, several thousand hedgehogs (*Erinaceus europaeus*) are taken into care following accident, sickness or failure to attain sufficient fatness (Morris 1984) to survive hibernation. The intention is to restore fitness to the animals and release them into the wild at a favourable time and place. Despite the high cost of this activity in time and resources, only three follow-up studies have been published confirming that this effort is justified and humane. It is important to ascertain whether rehabilitated hedgehogs can cope with release into the wild and that they do not suffer distress, disorientation and an early death.

A pilot study by Morris *et al* (1992) indicated that adult hedgehogs soon adjusted to an unfamiliar environment and became fully integrated with the social behaviour of wild

hedgehogs. However, they appeared to suffer progressive weight loss, and the investigation was terminated after 3 weeks, too soon to determine the ultimate fate of these animals. In subsequent studies in Suffolk (Morris *et al* 1993) and Devon (Morris & Warwick 1994) hedgehogs were monitored for over 2 months and demonstrated that, although substantial weight loss occurred initially, weights stabilized after about the third week following release. Moreover, the largest proportional losses were seen in the heaviest animals, which shed excess weight put on as a result of generous feeding in captivity. Even overwintered juveniles (with no previous experience of life in the wild) were able to find food, build natural nests and relocate them subsequently. They also integrated with local resident hedgehogs without evident signs of hostility and frequent cases of courtship behaviour were observed. Released captives appeared to be tame and significant numbers were lost to accidents such as being run over or killed by badgers. Perhaps these hedgehogs had become too trusting for their own good.

In both the Suffolk and Devon studies some of the hedgehogs made sudden, long-distance excursions away from the study area, possibly seeking more familiar habitat. It is important to know whether dispersal is a response to being translocated into unfamiliar habitat or part of a natural redistribution process. Perhaps animals need to be released in the same sort of habitat from which they originally came, and response to release differs according to the hedgehog's origin. When planning to release rehabilitated animals it is important to know whether or not they are likely to disperse, and if so how soon and how far. Otherwise the size of area needed for release and the provision of any support within it will remain a matter of guesswork.

Previous follow-up studies have monitored hedgehogs released into arable farm land and pasture, but many released hedgehogs come from semi-urban areas and would normally inhabit gardens. It would be valuable to know more about the activities of hedgehogs released into areas with houses and gardens. Do they simply find the nearest garden and settle down there? Are released hedgehogs more likely to be killed on the roads in a semi-urban environment?

In view of the small number of such studies hitherto performed, in 1995 a follow-up study of released hedgehogs was undertaken in Jersey with the following objectives:

1 To find out whether hedgehogs released at their original point of capture ('site-native') behave differently from those which originated elsewhere, particularly in relation to dispersal.
2 To establish whether availability of garden habitats influences behaviour and movements of released hedgehogs.
3 To discover whether release in a semi-urban environment results in high losses to road traffic.
4 To confirm that juvenile hedgehogs can survive release despite little or no previous experience of independent life.
5 To confirm that released hedgehogs interact normally and freely with resident animals.

This study was carried out at the request of the Jersey Hedgehog Preservation Society, in order to learn more about the fate of a small sample of the many animals that are cared for in Jersey (Channel Islands) and subsequently released there.

Materials and methods

The release site was a garden at Mont a l'Abbé, adjacent to gardens and farm land, with bramble scrub and woodland areas nearby. Most of the hedgehogs remained within the area bordered by the Vallee du Vaux road and the A9 St John's main road, ranging up to 600m north or south of the release point. This effectively defined a study area approximately 300m wide and 1200m long, 36 hectares of steep slopes, lawns, crop fields and gardens.

Thirteen hedgehogs (six male, seven female) were used. Six (three of each sex) were 'site-native', originating from the study garden. The others came from different parts of Jersey (see Table 1). All animals were born in late 1994 and had little or no previous experience of life in the wild. They had been kept indoors over winter, fed well, and in some cases, given veterinary treatment. Each was anaesthetized using halothane and fitted with a small radio transmitter glued directly to a patch of spines on the shoulders. Each transmitter operated on a unique radio frequency which identified the animal in the field and was the basis for the identity numbers in Table 1.

Table 1 **The study animals, their sex, origin and weight at release. X = site-native animals (originally from the study garden), O = originated elsewhere in Jersey.**

Animal no	Sex	Release weight (g)	Origin
210	M	1220	O
220	M	740	O
227	M	760	O
242	F	710	O
255	F	800	O
282	M	940	X
287	M	740	X
298	M	760	X
311	F	820	O
324	F	880	O
331	F	660	X
339	F	780	X
351	F	860	X

The hedgehogs were released together on the evening of April 4 1995 on the patio of the study garden. They were subsequently radio-tracked every night until April 23 (20 nights). Each night the animals were located and weighed. On most nights at least some animals remained inaccessible, but few went more than 3 nights without being weighed. The aim was to obtain position fixes for every animal at least three times each night, to know approximately what area each animal was using and to avoid losing contact altogether. Daytime resting sites were located in order to find out what sort of places were used and how often the same daytime sites were re-used. Actual nests were often not located exactly to avoid disturbance, but where radio signals indicated nesting in the same general area (eg the same clump of bushes) it was assumed that the same nest was used. In this context 'nests' mean 'daytime resting places' or 'lairs' (Reeve & Morris 1985). In a few cases the

hedgehogs remained in the same place for several days and the nests were then dug out (eg from rabbit burrows or bramble thickets) to ensure that the animals had not died. In fact these periods of inactivity represented temporary resumption of hibernation on cold nights, not fatalities.

After 20 nights' observations, surveillance was reduced to finding daytime nest sites only, with periodic recapture for weighing. Three hedgehogs were lost and two had their radios removed after 32 days. The remaining eight animals were located on the night of 19 May, 46 nights after release, or the following day. Their radios were removed and the study terminated just over 6 weeks from commencement. Subsequently (12 June) one 'lost' animal (210) was found, its radio batteries exhausted, on the north coast at Wolf's Cave restaurant feeding with feral cats.

Results

The fate and final recapture locations are shown in Table 2. Eight animals were recovered 6 weeks after release. Two of these (311 and 331) were within 20m of the original release point, five others were less than 250m away and the eighth was found at the Mont à l'Abbé school about 600m south. Three of the eight animals were site-native, five from elsewhere. Many of them had travelled 200m or more from the release point, but had returned and had frequently been found close to the release garden. A ninth hedgehog (number 210) was recovered later at Wolf's Cave, 5.2km away. All three of the animals which disappeared from the study area were males and originated from elsewhere in Jersey. However, the straight-line distance from the release point to the last point of capture for the six site-native hedgehogs did not differ statistically from the sample of seven animals from elsewhere (Mann-Whitney U test, $P = 0.6661$).

Table 2 **Last known location where the hedgehog was found active and the approximate distance from the release point. Some animals had the radio removed at the last location or were subsequently lost (L).**

Animal no	Sex	Last known location	Lost or radio removed	Nights after release	Approx distance from release point
210	M	Wolf's Cave	-	70	5200m N
220	M	Field	L	45	350m N
227	M	In farm log-pile	L	29	230m N*
242	F	Front garden by main road	-	46	250m SW
255	F	In rabbit burrow below field	-	46	120m SE
282	M	By garden shed	-	46	150m S
287	M	School car park	-	46	600m S
298	M	Near gardens, Beau Desert	L	32	800m N
311	F	Next garden to release site	-	46	20m E
324	F	Mont au Pretre	L	32	250m NE
331	F	At original release point	-	46	0
339	F	In garden	-	46	150m S
351	F	In garden	-	46	150m S

* Hedgehog extracted from burrow

All animals showed a marked association with gardens and hedgebanks, using open fields infrequently despite these offering larger areas in which to forage. However, the picture is distorted by the fact that a few very large gardens, comprising excellent hedgehog habitat, formed a significant proportion of the core of the study area. Nevertheless, the hedgehogs appeared to spend more time in the valleys and moist grassland areas of slopes and gardens than on the drier farm fields.

Survival

All the animals survived at least 4 weeks following release. Ten animals (77%) are known to have survived more than 6 weeks and there is no reason to suppose that the remaining animals were already dead or that accelerated mortality occurred after the study ended. Thus, the survival rate was high, despite the animals all being inexperienced juveniles.

Movements and nesting

Nest sites included rabbit burrows, holes in a hedgebank, a large log-pile and dense bramble thickets. All the hedgehogs managed to build nests or find secure daytime resting places and then find them again on subsequent nights. All managed to relocate a previously used daytime nest, having nested elsewhere for at least 1 day, sometimes over 200 metres away. This suggests that they quickly learned how to find their way about, regardless of whether they were site-native or new to the area. Each daytime nest was located and its position was recorded as map coordinates from which the distance of the nest position from the release point could be calculated, using Pythagoras' theorem. The results are shown in Table 3.

Table 3 **Distances (m) between release point and daytime nesting sites. The 'total nesting distance' is the sum of all the distances between the release point and each successive daytime nest site. Minimum, maximum and mean distances of daytime nests from the release point are also given.**

No	Sex	Origin	No of nest sites	Total nesting distance	No of nights tracked	Min-max distance	Mean distance ±SD
210	M	O	17*	4016*	27	100-293*	149±50*
220	M	O	14	6998	42	81-477	167±98
227	M	O	8	6801	27	130-393	252±51
242	F	O	11	5863	44	20-278	133±38
255	F	O	7	2352	46	10-139	52±39
282	M	X	27	6200	35	108-456	177±101
287	M	X	21	11369	36	117-546	316±59
298	M	X	19	4864	30	110-866	162±135
311	F	O	11	5254	44	42-150	119±15
324	F	O	18	5420	31	100-378	175±89
331	F	X	12	7483	45	10-211	166±40
339	F	X	21	5456	42	45-197	130±19
351	F	X	15	7374	45	110-376	164±38

SD – standard deviation

* Only includes nest sites on the study area, ie excludes nests and time spent between study area and Wolf's Cave, where its movements were unknown.

If site-native animals stayed close to the release point, but non-native individuals progressively moved away, perhaps seeking more familiar terrain, then differences in nesting distances should become apparent. However, there was no statistically significant difference between the site-native animals and those originating elsewhere in respect of the nearest nest, furthest nest or mean nest distance from the release point (Mann-Whitney U test, P = 0.3901, 0.3173, 0.3914 respectively).

In Table 3 the mean nesting distances from the point of release are shown, together with the standard deviation. From these, a coefficient of variation (CV) can be calculated, being the standard deviation as a percentage of the mean. Again, if the site-native animals were 'more at home' they might be expected to move about less than animals originating from elsewhere. In fact the average CVs for the two groups were very similar (36.8 per cent and 39.9 per cent respectively), with males being more varied in their nesting positions than females, regardless of origin (mean CV 45.2 per cent for males and 32.7 per cent for females).

Reeve and Morris (1985) showed that male hedgehogs change their nests more frequently than females. A similar pattern was seen in the present study, with males using the same nest for an average of 2.09 days and females 3.58 days, irrespective of their origin. If the site-native animals were 'more at home' than those from elsewhere, they might be expected to remain in the same nests for longer. In fact the reverse was true (see Table 4), but sample sizes were too small for the differences to be statistically significant.

Table 4 **The mean number of nights per daytime nest as an index of the frequency of nest changes.**

	Males	Females
Site-native animals	1.53	2.92
Animals originating elsewhere	2.65	4.07
Mean	2.09	3.58

Many hedgehogs settled down quickly and did not wander away. The five animals that did nest more than 400m from the release point stayed closer than that for at least 30 days before moving away. All five were males, three site-native and two from elsewhere. Five animals were regarded as 'lost' (Table 2), having apparently disappeared off the study area or had their radios removed before they went too far away to be monitored reliably. Of these five, four were males (including 210, found later at Wolf's Cave), but only one (298, a male) was site-native. The sample size is too small for certainty, but it appears that sex had more effect on movements than origin.

Weight changes

The six released males had a mean weight of 860g and the seven females 787g, a difference which was not statistically significant (Mann-Whitney U test, P = 0.8861). In contrast a

sample of 26 wild males found during the study (mean weight 966g) weighed significantly more than six wild females which averaged 633g ($P = 0.0032$). The released males were smaller than their wild counterparts, but released females were larger. However, the differences were not statistically significant (males $P = 0.2875$, females $P = 0.0865$). It could be concluded, therefore, that the released animals were 'normal' but they were all less than a year old, whereas the wild ones found during the study included many full adults and were therefore likely to vary more in size. The released animals were generally large for their age, at least 50 per cent heavier than might be expected of wild yearlings at this time of year (cf Morris & Warwick 1994).

As in previous studies the released hedgehogs lost weight initially, particularly in the first 10 days. Most stabilized within 3 weeks having lost 10–20 per cent of their release weight. This should be seen in the context of the large fluctuations that were apparent, often 5–10 per cent change between successive nights. As in an earlier study (Morris & Warwick 1994), it was the largest animals which lost the most weight relative to their initial size. This relationship is highly significant, both statistically ($P < 0.005$) and in practical terms as it indicates that the hedgehogs were shedding excess mass accumulated in captivity rather than progressively starving to death. Seven of the thirteen animals lost a maximum of 20 per cent of their weight but most recovered at least part of the loss.

Only one (no 282) of the thirteen animals showed progressive and continued weight loss throughout the study, being 35 per cent smaller after 6 weeks than at release. Others remained remarkably constant in weight: after the first 2 weeks number 242 remained around 600g for the ensuing month and the weight of number 331 varied by less than 10 per cent throughout the study. Two others (287 and 298) both attained a greater weight than at release, indicating considerable success in feeding.

Despite losing weight initially, and in some cases for a protracted period, none of the released animals was seen to use the food bowl that was put out each night at the release point, although wild hedgehogs continued to do so.

Interactions with wild hedgehogs encountered on the study area

At least 30 wild hedgehogs were already living on the 36 hectare study area in addition to the 13 released animals. Many of these were encountered accidentally during the study and it is likely that others were present but not seen. The radio-tracked hedgehogs were each located several times per night and were often found in the company of other hedgehogs. This is not surprising as April marks the beginning of the breeding season for this species (Morris 1983) and it was mostly male-female pairs that were observed, often overtly engaged in courtship behaviour. There must have been many more interactions that were not seen, having taken place in the intervals between monitoring released hedgehogs. No aggressive interactions were encountered.

Table 5 summarizes all observed social activity. Clearly the released hedgehogs were interacting with wild hedgehogs as much as with fellow former captives.

Table 5 Interactions between released hedgehogs and others.

Animal no	Sex	Seen with	Sex
227	M	a wild hedgehog	M
242	F	wild no 84	M
351	F	wild no 84 (on 3 different nights)	M
311	F	a wild hedgehog	M
339	F	wild no 84	M
324	F	282 and a wild hedgehog	both M
282	M	324 and a wild hedgehog	F & M
298	M	a wild hedgehog	M
287	M	a wild hedgehog	F
282	M	351	F

Discussion

Clearly these animals adjusted quickly and successfully to release, despite the fact that all were juveniles with little or no previous experience of independent survival in the wild. This is welcome confirmation of previous studies. It is also encouraging to confirm that weight loss following release is related to release weight. It represents the shedding of excess mass accumulated during captivity, when food supplies are generous and opportunities for exercise are few. Weight loss following release is therefore not a cause for alarm and may be expected to stabilize within 2–3 weeks.

The relatively sandy soils of Jersey might offer fewer earthworms and other food items than richer soils elsewhere. It is therefore interesting, and encouraging, that maximum weight loss was generally less than in juvenile hedgehogs of similar size released on grazing land in Devon (Morris & Warwick 1994). However, later in the season the plateau land of Jersey might become exceedingly dry and offer little or no food for hedgehogs. Even at the time of the study, when the ground was often wet with dew, the hedgehogs appeared to frequent the moister gardens in preference to the large areas of (drier) open fields available to them. If hedgehogs are released in the summer months, this should be taken into consideration when release sites are selected.

These hedgehogs, like those released in previous studies, were able to build natural nests and to find them again without evident difficulty. This applied to the site-native animals and equally to those unfamiliar with the release area. Moreover, the released animals, irrespective of origin, seemed to integrate socially with resident hedgehogs and with each other. There was no evidence of territorial aggression. This is despite a very high population density (in excess of one per hectare on the study area as a whole), especially in the vicinity of the release site, where supplementary feeding took place.

Jersey has no large terrestrial predators, so the high levels of mortality due to badgers experienced in Devon (Morris & Warwick 1994) were unlikely to be repeated. However, the Jersey study site was bordered by two roads, both heavily used until at least midnight. Several smaller roads crossing the study area were also used by at least 20 vehicles per

night. In terms of the danger of death from road traffic, this site represented a more 'urban' situation than those used in previous studies in Devon, Suffolk or Yorkshire. Road casualties were expected among the study animals, especially as several of them crossed roads frequently and were often found alongside the roads with street lamps. Despite the danger, none of these animals were killed in the 6-week study period. Extensive searches were made by road for the lost animals but, although dead hedgehogs were encountered, none were from the released group. This suggests that release into an area with roads is not necessarily ill-advised, even for naïve juvenile hedgehogs. In fact it would be difficult in Britain (and impossible in Jersey) to find release areas that did not have roads within a normal night's range of a hedgehog. Nevertheless, it may be unwise to release hedgehogs into fully urbanized areas where roads (and traffic) are a dominant factor in the environment. This is especially so if hedgehogs are prone to disperse after release.

A major objective of the study was to discover whether the origin of animals affected their movements after release. In particular, release projects need to be planned knowing whether hedgehogs from elsewhere tend to travel further (exposing themselves to greater dangers) than those released into areas already familiar to them. In fact there was no evidence that dispersal behaviour, and the associated risks, differed between site-native animals and those originating elsewhere in Jersey. It is true that the animals which dispersed furthest were not from the release site. However, they were also males and might be expected to move about more in any case. The study suggests that a hedgehog's sex might affect dispersal behaviour as much as its origin.

The general pattern of behaviour was for animals to settle down within 400m of the release point. Those that did disperse further had nevertheless remained within that distance for at least 4 weeks before leaving the study area. This may suggest that dispersal is a natural feature among hedgehogs and was not a result of displaced animals wandering widely in an attempt to return 'home' to their real place of origin. Long-distance dispersal movements might be expected among males at the beginning of the breeding season, especially those attaining sexual maturity for the first time (as was the case in the present study). However, in a similar study of released yearling hedgehogs (Morris & Warwick 1994), the three animals that undertook sudden, long-distance dispersal movements were all females.

The possibility exists that hedgehog populations include a proportion of transient animals or residents which are predisposed to emigrate, perhaps in response to high population density (and potential competition for resources). High densities were a feature of all the release studies referred to above. If hedgehog release sites are selected on the basis of being good hedgehog habitat, they are likely to have a significant resident population already present. Adding more might be expected to result in some animals dispersing. There is no reason why at least some hedgehogs should not disperse widely. Defence of territory, nests, food or other environmental resources does not appear to be a feature of hedgehog biology, so there is little reason to remain in one place.

Overwintered juveniles were selected for the study in order to remove age as a potentially significant variable and also because these might be expected to move about less than adults, making it easier to radio-track a larger sample. However, juveniles have had less opportunity to become imprinted on a particular area, so the difference between site-native animals and those from elsewhere might not be great. This weakness in the design of the experiment is

offset by the fact that if adults had been used (assuming they had been available), and the males were as active as some in previous studies, a few individuals would have consumed disproportionate amounts of radio-tracking effort, leading to uneven monitoring of the release group. It is likely that some would have quickly been lost, thus weakening the study in a different way.

Investigations such as the present one would benefit from using larger sample sizes. However, it is not easy to obtain larger samples, especially if sex ratio or sites of origin need to be considered. Keeping track of 13 animals was difficult and more than 15 would have lengthened intervals between finding individuals with a commensurate increase in the risk of losing them altogether as they moved out of detection range. It would have been more difficult still if they had been adult males or had scattered radially instead of remaining in fairly consistent areas. The experiment was designed to play safe in these respects, yet several animals were lost nevertheless.

There remains a question mark over the fate of hedgehogs released into urban sites. Many are set free in parks, playing fields and cemeteries which are completely enclosed by roads and other barriers. The present study (and others) suggests that at least some animals are likely to disperse. In a built-up environment this must surely increase the risk of death from road traffic. Moreover, dispersing animals are unlikely to find suitable new habitat within a short distance. Do they then continue to roam, looking for it, do they attempt to settle in unsuitable places or do they return to the release site? Such questions will not be easy to resolve as radio-tracking hedgehogs in the built-up environment is difficult.

Conclusions and animal welfare considerations

This study has demonstrated that:

1 Hedgehogs can cope well with release into the wild following long periods in captivity. Even juvenile hedgehogs with little or no previous experience of life in the wild can successfully build and use nests, find their way about and obtain sufficient food. Released animals integrate well with resident wild hedgehogs without evident aggression.
2 Initial weight loss occurs, but stabilizes after 2–3 weeks. It is not a symptom of starvation but represents the loss of excess weight gained in captivity.
3 These findings provide important confirmation of previous studies and valuable reassurance that releasing captive hedgehogs into the wild is not contrary to their welfare interests. Time and effort spent in rehabilitating hedgehogs are not wasted as a result of early death.
4 There is no conclusive evidence that, with juvenile hedgehogs at least, site-native animals behave any differently to individuals translocated from elsewhere. Certainly animals originating elsewhere do not immediately embark on 'homing' journeys or travel further looking for more familiar terrain.
5 While some dispersal movements were seen in the present study, and several involved non-site-native animals, it is likely that a hedgehog's movements post-release will be influenced as much by its sex as its origin.
6 All of the released animals remained within 400m of the release site for at least 4 weeks, irrespective of sex or origin. Most were still within that distance after 6 weeks and several remained within 200m of the release point. Nevertheless, one animal emigrated over 5km and three others were lost and may well have travelled as far or even further.

7 Released animals showed a preference for living in moist garden habitats. Open fields were less attractive to them. They nested in bushes, hedges and rabbit burrows, under tree roots and garden sheds. The need for such features (and size of area) should be borne in mind when planning releases.
8 Despite losing weight, the hedgehogs did not make significant use of supplementary food, even though it was available. Its provision is therefore not an essential requirement for successful rehabilitation.
9 Despite the hedgehogs being naïve juveniles and the considerable time some spent close to busy roads, none were killed by traffic. It is probably unrealistic to attempt releases out of range of roads; other environmental features are more important (eg nest sites, food supplies).

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