Survival and weight changes of hedgehogs (*Erinaceus europaeus*) translocated from the Hebrides to Mainland Scotland

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Abstract: Hedgehogs (*Erinaceus europaeus*) are being killed on the Uists, in the Outer Hebrides, Scotland, in an attempt to improve the breeding success of ground nesting birds. Translocation of hedgehogs was considered as an option, but dismissed on welfare grounds. The principal concern was that translocated animals would starve. The present study set out to test this hypothesis. Twenty hedgehogs from the Uists were released on the Scottish mainland at Eglinton Country Park, Irvine and radio tracked for a month to ascertain whether or not the animals were going to starve in their new environment. Seven of the twenty radio tracked hedgehogs showed significant weight gains, five maintained their weight, and three lost weight. Two of the hedgehogs that lost weight died during the study. There were three early deaths from predation and drowning, one from a pre-existing tumour. If these deaths and the individual that vanished on the first night are removed from the analysis the results indicate an 80% survival rate one month after translocation. If all early deaths by predation and drowning are attributed to the unfamiliarity of the translocated hedgehogs with the terrain, the survival rate is 67% one month after translocation. The data also indicate that there is an advantage for females to weigh at least 550 g on release. Although conclusions should be drawn with care due to the limited sample size, study period and research approach our study suggests that concerns over the welfare of translocated hedgehogs are not well-founded, thus questioning the principal objection to such an undertaking.

Keywords: hedgehogs, radio-tracking, translocation, cull, Uists, wildlife management.

Introduction

Hedgehogs (*Erinaceus europaeus*) are being killed on the Uists, in the Outer Hebrides, Scotland, in an attempt to improve the breeding success of ground nesting birds. The Uists support an internationally important bird fauna, with at least 17,000 pairs of nesting waders, including about 25% of the total UK breeding population of dunlin (*Calidris alpina*) and ringed plover (*Charadrius hiaticula*) (Fuller et al. 1986).

A study by Jackson & Green (2000) suggested that nesting success had significantly declined during the 1980s and 1990s, following introduction of hedgehogs to South Uist in 1974. Although other predators were also present, notably an introduced population of American mink (*Mustela vison*), hedgehogs were implicated in significant levels of nest predation. Experimental removal of hedgehogs resulted in improved nesting success (Jackson 2001) and several possible courses of action were considered (Uist Wader Project 2002). Scottish Natural Heritage (SNH) is ultimately responsible for wildlife conservation on the islands and decided to attempt the eradication of the hedgehog population by capture and humane destruction. In four successive years (2003-2006), SNH has conducted hedgehog removals, with the animals being humanely killed by lethal injection after being found by employees, walking through the fields at night equipped with powerful torches. A six-week capture 'window' in April and May was used; any earlier and most animals would be still hibernating and later might entail deaths of lactating females and consequent starvation of their young. In the four years of operation SNH have killed 658 hedgehogs.

The decision for such culling was opposed by

"Uist Hedgehog Rescue" (UHR), a consortium of NGOs comprising of the British Hedgehog Preservation Society, Advocates for Animals, Hessilhead Wildlife Rescue Trust and International Animal Rescue. While accepting that hedgehogs were a problem and should be removed, UHR argued that they should not be killed, but be captured and taken to the mainland to be released alive.

The decision to kill the hedgehogs, as opposed to translocating them, was taken partly because of a fear that translocated hedgehogs might suffer in some way. SNH stated that moving animals to the mainland would be cruel as it will cause many slow and lingering deaths due to starvation, injury or illness (Uist Wader Project 2002; G. Anderson, personal communication). These assumptions, however, run counter to the results of recent studies of translocated hedgehogs, which show substantial survival rates among animals that have spent long periods in captivity (Morris et al. 1993, Morris 1998, Reeve 1998). Even juveniles with no experience of independent life in the wild can cope well with release in unfamiliar sites (Morris & Warwick 1994, Morris 1997). Several animals removed from the Uists in previous years that were marked and released on the mainland are known to have survived at least until the following year (A. Christie, Hessilhead Wildlife Rescue Trust, personal communication).

Our objective is to test the claim that translocated hedgehogs might suffer unacceptably and die as a result of translocation. The study can be best described as a pilot-study in which we follow up what happened to a sample of animals translocated from the Uists to the mainland in April 2005. Hence this was not a classic experiment with controls, but an investigation into what would happen to the animals if released following the protocols envisaged by the parties that are in favour of translocating instead of culling the Uist hedgehogs.

During the health check, conducted on the hedgehogs while unconscious, the state of their teeth was checked. *Photograph: Hugh Warwick.*

Methods

Hedgehog translocation

Twenty female hedgehogs were used for this study. They had been found on the Uists between 1st and 23rd April 2005 and were likely to be only recently out of hibernation. UHR volunteers and local members of the public, principally on South Uist, obtained the animals. UHR provided a briefing to everyone collecting hedgehogs for translocation before accepting them into the 'bounty scheme', in which £20 was paid for each hedgehog found and delivered to a reception centre in a healthy state. The hedgehogs were then transported to the mainland and held at Hessilhead Wildlife Rescue Trust until the start of the study. The staff at Hessilhead release 200-300 hedgehogs back into the wild, each year, excluding >700 translocated Uist hedgehogs in the years 2002-2005 that also passed through the hospital (A. Christie, personal communication).

Female hedgehogs were used as they are known to travel less far each night (Reeve 1982, Morris 1988), thereby making it possible to monitor a larger sample than if males had been included. Using only a single sex also removed one source of potential variables in the results of the study.

On the evening of the 27th April 2005 the 20 hedgehogs were given a health check under anaesthetic (isoflurane), as advocated by Sainsbury et al. (1996). They were weighed, had their temperatures taken (electronic rectal thermometer), had their teeth checked and were also

Eglinton Country Park, in which the Uists hedgehogs were released. *Photograph: Hugh Warwick.*

searched for signs of injury and ecto-parasites. Un-fit animals would not be released, following the protocol for the proposed translocation programme.

The hedgehogs were left at Hessilhead for a night to recover from the anaesthetic. On 28th April the first ten hedgehogs were taken by car, in cardboard pet carrying cases, to the release site at Eglinton Country Park (OS Grid Reference 232120,642280). This 400 hectare site was chosen after the recommendation of staff at Hessilhead and a reconnaissance trip carried out in April 2005 that revealed it to be a varied and suitable habitat. The second batch of ten was released on the 30th April. The principal reason for staggering the release was to assist the radio-trackers to become familiar with the site. The animals were released at two sites within the park. One was at the base of a hill in an area of mown grass rides and 20+ year-old mixed woodland. The second location was in a pasture about 400 metres away, to the north and beyond a small river. Half of the animals from each batch were released at each site.

Radio-tracking and sampling

While the hedgehogs were unconscious for the health check a radio transmitter ('Biotrack', Wareham, Dorset, weight 10 g) was attached. A small group of spines on the back of the hedgehog were clipped to create a flat bed, on to which the transmitter was glued using epoxy resin applied to the front and sides of the transmitter. The glue did not touch the animal's skin, the points of attachment being the uncut spines surrounding the transmitter. The transmitter's unique radio frequency became the animal's identity number used in this paper.

The radio-transmitters were applied to the hedgehogs while they were still unconscious, following their health check. They were kept warm on heating pads and held firmly as they awoke to allow the glue to set. *Photograph: Hugh Warwick.*

The hedgehogs were monitored every day and night for four weeks. The intention was to capture and weigh the animals nightly and to locate their daytime resting places. In practice, it was not always possible to find all the hedgehogs every night. In part this was due to the speed and radial nature of their dispersal, but sometimes animals were temporarily unrecoverable from thick shrubbery. The other main cause of incomplete data was hedgehogs being active among livestock that the researcher had been asked not to disturb.

The radio-tracking was carried out using a TRX-1000S receiver (Wildlife Materials Inc, Illinois, USA) and a Folding 3-Element Yagi Directional Antenna. Daytime resting sites were identified, mainly to assist the evening work, as they indicated whether the hedgehogs had moved substantial distances since the last time they were located. At night the position of each hedgehog was noted and its position recorded as six-digit coordinates taken from a 1:10,000 OS map. Each animal was weighed at each capture using a 'Pesola' spring balance (weighing to 1000 g, with 10 g divisions), giving an indication of general body condition and confirming that the animals were or were not maintaining their weight by successful feeding. Body mass was taken to be the clearest indication of general health and the ability to thrive. If the animals were failing to thrive in their new environment this would either reduce the amount they ate, or they would cease to feed. Either way their body weight would decline.

Hedgehog 234, found with head bitten off on the day after release. Probably killed by a dog as it was found in an area frequented by dog-walkers. *Photograph: Hugh Warwic*k.

After four weeks the radio-transmitters were removed from the hedgehogs after their final weight had been taken. The transmitters were removed using sharp-nosed wire cutters to sever the spines attached to the device.

Any indigenous hedgehogs found were also weighed and given an individually recognizable identification mark with spots of paint on the spines. All observed interactions between indigenous hedgehogs and translocated females were documented.

Analysis

The three hedgehogs that all died within a week of release (234, 274, 204), and the one that disappeared within 48 hours (337), were excluded from the analysis of trends in weight changes due to insufficient data points. Hedgehog 395, which was known to have died of disease (see below), was also excluded from the analysis. The weights of all the remaining 15 hedgehogs were plotted against time, with their weight at release assigned to day 0 in each case. Simple linear regressions were calculated for each animal using Microsoft Excel. The regression slopes indicate weight gain/loss per day for each individual. The null hypothesis would be that weights neither increased nor decreased with the passage of time (i.e. the slope of the calculated regression line does not differ significantly from zero). This was tested by ANOVA and statistical significance of the observed difference was measured by F values and deemed significant where $F<0.05$.

Results

Weight gain in captivity

Following capture in the Uists, all but one of the hedgehogs showed substantial weight gains in captivity, up to about 50% in two and over 30% in four others (table 1). Mean weight gain was

Table 1. A comparison of the initial weight (at capture) with the actual weight at release, final weight from the field and the fate of the translocated hedgehogs.

Animal	Date of capture	Capture weight (g)	Release weight (g)	% weight change in captivity	Last weight in field (g)	% weight change in fiel	Fate
204	18-Apr	470	606	29			Drowned on day 5.
213	23-Apr	458	542	18	510	-6	Returned to rescue centre on day 26; died on day 27. Cause of death: diarrhoea.
234	15-Apr	520	684	32			Killed by predation on day 1.
243	17-Apr	450	570	27	630	11	Survived.
253	04-Apr	535	656	23	850	30	Survived.
267	20-Apr	510	564	11	630	24	Survived.
274	06-Apr	355	539	52			Killed by predation on day 4.
284	23-Apr	550	599	9	630	5	Survived.
295	13-Apr	405	529	31	590	12	Survived.
305	24-Apr	510	535	5	380	-29	Returned to rescue centre on day 13; died on day 14. Cause of death: unknown.
314	18-Apr	475	576	21	710	23	Survived.
326	01-Apr	620	610	-2	750	23	Survived.
337	16-Apr	735	802	9			Vanished.
344	18-Apr	515	616	20	850	38	Survived.
355	18-Apr	480	563	17	630	17	Survived.
363	11-Apr	465	560	20	510	-9	Returned to rescue centre on day 10 with ticks; then re-released on day 21.
374	18-Apr	425	634	49	690	9	Survived.
385	11-Apr	365	497	36	430	-13	Survived.
395	15-Apr	550	647	18	490	-24	Died on day 15, tumour on bladder.
404	10-Apr	540	722	34	820	14	Survived.

23%. The weight loss of the one animal that lost weight (no. 326) was 1.6%, well within normal daily fluctuations for an animal this size

Survival after translocation

Hedgehog 337 was released, but no trace of it was ever found again due to either radio transmitter failure or very rapid dispersal. Six of the released hedgehogs died in or soon after the study period. Hedgehogs 234 and 274 were found dead one and five days after release respectively, with injuries indicating predation by dog or badger (*Meles meles*). Hedgehog 204 drowned in the river six days after release. Hedgehog 395 was found dead on day 15; a post mortem examination showed a distended bladder associated with a large tumour. Hedgehog 305 maintained her weight for a week before starting to lose weight and subsequently dying after return to the wildlife hospital on day 13. Hedgehog 213 was brought

Table 2. Regression analysis of weight gain/loss against time for 15 female hedgehogs tracked for up to 28 days after translocation (in order of daily weight gain). CC = correlation coefficient; **: $P<0.01$; *: $P<0.05$; NS: $P>0.05$.

Hedgehog	Weight gain/loss (g/day)	Number of days sampled	Sampling period (days)	r^2	CC	P
344	5.6	17	28	0.79	0.89	**
253	4.4	23	28	0.71	0.82	**
404	3.9	21	28	0.70	0.86	**
326	3.6	20	28	0.58	0.72	**
314	2.9	23	28	0.56	0.75	**
374	2.8	20	28	0.39	0.63	**
355	1.9	23	28	0.25	0.50	*
295	0.5	18	28	0.03	0.17	NS
267	0.4	21	28	0.42	0.09	NS
363	0.3	11	18	0.004	0.07	NS
243	-0.5	28	28	0.014	-0.21	NS
284	-1.2	25	28	0.14	-0.58	NS
213	-2.3	19	25	0.26	-0.51	*
385	-4.0	20	28	0.57	-0.76	**
305	-11.9	10	13	0.75	-0.87	**

back to the wildlife hospital on day 26 and died soon after.

If the three early deaths from predation and drowning, the animal that died from a pre-existing tumour and the individual that vanished on the first night are removed from the analysis the results indicate an 80% survival rate one month after translocation. If all early deaths by predation and drowning are attributed to the unfamiliarity of the translocated hedgehogs with the terrain, the survival rate is 67% one month after translocation.

Weight gain after translocation

Besides the hedgehog that vanished the first night, the data from the hedgehogs that died early from predation, drowning or from the pre-existing tumour on the bladder were incomplete and thus not included in the weight gain analysis. Of the remaining 15 released female hedgehogs eleven gained weight and four lost weight during the study period (table 1). Of the hedgehogs that gained weight one animal (hedgehog 344) was 38% heavier at the end of the study compared to its release weight, and four others gained in weight by at least 20%. Of the animals that lost weight, one animal (hedgehog 305) had lost almost 30% of its body weight, while the others lost 13% or less (table 1).

Based on significant differences in weight gain/loss the animals can be divided into three groups (table 2): (1) Seven animals (hedgehog 344, 253, 404, 326, 314, 374, 355), showed average weight gains of between 1.9 and 5.6 g per day over the 4-week study period. Their weight gains were consistent and statistically significant when tested against the baseline 'no change in weight'. (2) Five animals (hedgehog 295, 267, 363, 243, 284), showed only small daily increases in weight, or small losses. Their weight changes, however, were not significantly different from staying the same. (3) Three animals (hedgehog 385, 213, 305) showed a statistically significant trend towards weight loss during the study period. For hedgehog 385 and 305 no particular cause of weight loss could be assessed. Hedgehog 213 appears to have lost weight particularly on the last two nights. Until then her body weight had remained relatively constant, fluctuating by only about 5% around the mean. However, she had been frequently active in daylight, often a sign of illness, and she was taken back into captivity on the 25th day, and died there soon after. A post mortem revealed that she had suffered severe diarrhoea.

Figure 1. Weight changes in translocated hedgehogs in relation to initial release weight.

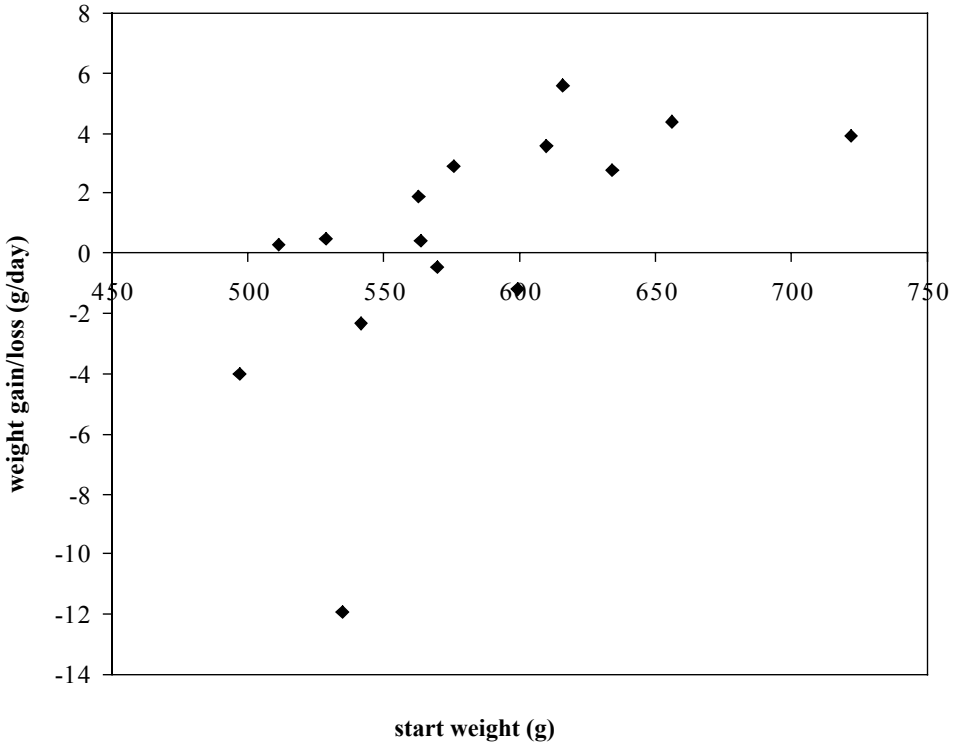

Figure 2. Percentage change in body weight in the field compared with the time spent in captivity prior to release.

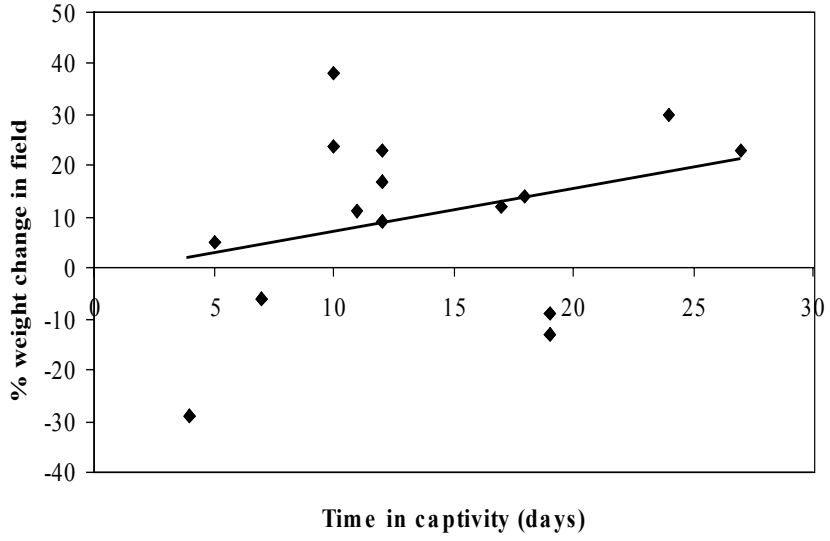

Table 3. Weights (g) of indigenous male hedgehogs caught during the study.

Male	Weight (g)							
	Capture 1	Capture 2	Capture 3	Capture 4	Capture 5	Capture 6	Capture 7	Capture 8
1	830	850	830	790	870	-	-	-
2	900	920	910	-	-	-	-	-
3	760	760	730	-	-	-	-	-
4	730	-	-	-	-	-	-	-
5	870	830	840	840	850	820	820	850
6	960	980	970	-	-	-	-	-
7	810	850	-	-	-	-	-	-
8	870	-	-	-	-	-	-	-
9	810	-	-	-	-	-	-	-

Table 4. Association matrix showing which of the released females were found with each of the indigenous male hedgehogs encountered on the site. Numbers in the grid refer to the number of nights that particular hedgehogs were found together.

Females	Males								
	1	2	3	4	5	6	7	8	9
204	-	-	-	-	-	-	-	-	-
213	-	-	-	-	-	-	-	-	1
234	-	-	-	-	-	-	-	-	-
243	-	-	-	-	-	-	-	-	-
253	-	-	-	-	-	-	-	-	-
267	-	-	1	-	-	-	-	-	-
274	-	-	-	-	-	-	-	-	-
284	1	-	-	1	-	-	1	-	-
295	-	-	-	-	4	-	-	-	-
305	-	1	-	-	-	-	-	-	-
314	1	-	-	-	-	-	-	-	-
326	-	-	-	-	-	2	-	-	-
337	-	-	-	-	-	-	-	-	-
344	1	-	-	-	-	-	-	-	-
355	-	-	-	-	-	-	1	-	-
363	-	-	2	-	2	1	-	-	-
374	-	-	-	-	1	-	-	-	-
385	1	2	-	-	-	-	-	-	-
395	-	-	-	-	-	-	-	-	-
404	-	-	-	-	-	-	-	-	-

Trends in weight change should also be viewed in relation to normal hedgehog weights at this time of year, when females generally weigh between 400 and 600 g. Several of the Uist animals used in the present study exceeded 600 g because we selected the largest animals available on the assumption that their fat reserves and general body condition were likely to be optimal. In figure 1 initial body weights at the moment of release are plotted against mean change per day during the study. All animals that lost weight were less than 600 g at the time of release. Of these, the three animals that lost most weight (>2 g per day) were less than 550 g at the start. Two others with a release weight of less than 550 g gained weight, but weight gain was less than 0.5 g per day. One of these (hedgehog 363) was temporarily taken back into captivity for ten days after she was found with a severe tick infestation. This might suggest that animals weighing less

Hedgehog 385 by a very busy road. It was disturbed in the day to check that the signal was not coming from a corpse. *Photograph: Hugh Warwick.*

than about 550 g should not be released without a period of fattening up in captivity.

Another contention has been that the amount of time spent in captivity may have an impact on the survival of translocated hedgehogs (Molony et al. 2006). As figure 2 indicates, there was no correlation (correlation coefficient = 0.31) between the amount of time spent in captivity and the percentage weight change in the field for the translocated hedgehogs from the Uists.

Weight gain of indigenous hedgehogs

Nine indigenous male hedgehogs were found during the study. All but one (male 8) discovery of an indigenous male was made in conjunction with a radio-tracked female. No wild female hedgehogs were found during the study. The weights of each male hedgehog (table 3), while not presenting enough data to analyse robustly, do not suggest that the resident male population of hedgehogs was losing weight following the release of 20 females. For animals we captured two times or more (male 1, 2, 3, 5, 6 and 7) the mean change in weight between the first and last measurement was about +8 g.

Interactions with indigenous hedgehogs

The released animals appeared to interact normally with the indigenous male hedgehogs found in the study area during the study period. April is the beginning of the hedgehog breeding season, when pairs may be expected to perform 'courtship' rituals (Morris 1983). Eleven of the released females were found consorting with wild males at various times. Hedgehog 295 was found courting with male 5 on four occasions

and hedgehog 363 twice with male 3, twice with male 5 and once with male 6. Table 4 shows an association matrix from which it is evident that both males and females were behaving promiscuously, as is normal (Reeve & Morris 1986).

Discussion

The limited resources available precluded a longer study period. However, our data supports the assumption that twenty-eight days is long enough to observe signs of starvation in translocated hedgehogs or other acute responses to the translocation. Observed daily movements and interactions with indigenous hedgehogs also suggest that the length of the study period was sufficient to indicate whether the translocated animals were adapting to life in their new surroundings.

Limited resources did not allow for the monitoring of the indigenous population as a control. Only accidental encounters with indigenous hedgehogs were used to collect data on weight changes in the native population. Therefore we cannot draw conclusions as to the impact of the translocation on the welfare of individuals in the native population beyond that presented by these data. And this was additionally limited by the absence of any data from indigenous females. However, the data that was collected from the native population did not suggest any weight loss.

A sample size of 20 animals was considered to be the maximum number that could be radio-tracked in this pilot-study, given the facilities and equipment available, and given the desire to locate each animal at least once every night. There was also a limit to the number of female hedgehogs that could be captured in the three weeks prior to the start of the study. A larger sample was desirable as it would have generated a more robust study. However, previous experience indicated that, without more trackers and better receivers, there was a high probability that many hedgehogs would soon be lost due to the trackers' inability to keep up with so many animals if they dispersed radially into the surrounding countryside.

In the rescue centre, prior to release, all but one of the animals gained weight substantially (table 1). While weight loss is not specifically an indicator of stress, weight gain is an indicator of low stress. This would suggest that the capture, transportation and confinement prior to release raised no major welfare concerns.

Visiting Eglinton Country Park in early April raised concerns about the danger posed by the busy dual carriageway on the southern boundary to the park. However, during the subsequent study, none of our radio-tracked animals was killed on local roads, despite heavy traffic. The combination of positive factors in the park, including good mixed habitat and hedgehogs having been seen there by park rangers suggested it was a suitable location for release. Species with similar dietary requirements were also present, e.g. moles (*Talpa europaea*) and curlews (*Numenius arquata)*, suggesting that suitable food was available.

Two released animals were lost to predators, one being killed but not eaten, another being consumed totally, apart from the skin. Dog predation on hedgehogs released into suburban parkland has also been reported by Doncaster (1994). Predation by badgers is also possible (and eliminated 25% of released juvenile hedgehogs in a previous study; Morris & Warwick 1994), but badgers had not been seen locally. The remains of two indigenous (i.e. non-Uist) hedgehogs were also found, suggesting that predation was not uncommon here. These cases of predation of translocated hedgehogs may be regarded as accidental losses, not related to the origin of the animals, together with one (hedgehog 204) that drowned. However, a relation with the translocation cannot be completely excluded.

One animal (hedgehog 395) that died during the study period had a tumour, probably already present when the study began, and was thus excluded from the analysis. For two others (hedgehog 213 and 305) it could not be assessed with certainty whether their illness was present before the start of the study. Hence these animals were included in the analysis.

Notwithstanding the losses, this study clearly

showed that seven out of the 20 animals increased their body weights significantl , despite the unfamiliar terrain, an indication that their release was successful. A further five managed to sustain their weight. Thus more than half of the animals released failed to fulfil the prediction of SNH that translocation leads to slow and lingering death. Given that criterion, they could be said to have been translocated successfully. The Scottish Society for the Prevention of Cruelty to Animals, who have supported the cull while they remain satisfied that the welfare of the hedgehogs was not greatly compromised, defines a successful translocation as one with 60% survival (M. Flynn, personal communication). If the three accidental losses are removed, along with the one with a pre-existing tumour and the hedgehog that vanished, the sample size reduces to 15. Of these, 80% were successfully translocated from the Uists to the mainland, i.e. with maintaining or increasing their body weight.

It is tempting to try to identify potential 'winners' and 'losers' based on body weights before release. However, as consideration of figure 1 makes clear, a firm distinction is difficult. While it is true that all the animals whose body weight exceeded 600 g at release were survivors, using this weight as the cut off below which animals ought not be released would mean that the majority of hedgehogs at this time of year fell into that category. Most wild hedgehogs weigh substantially less than this in April, and many probably die, but a large proportion must survive. Thus it seems unlikely that a simple body weight measure can be used with confidence to predict survival of translocated hedgehogs, except for the largest animals. However, it does appear that a weight greater than 550 g is advantageous (in females at least).

Conversely, the smaller hedgehogs can be identified as liable to be at risk. The two smallest animals in the present study gave greatest cause for concern. Hedgehog 363 was released weighing 511 g and showed a mean weigh gain of 0.3 g/day but this is including ten days of fattening up in the wildlife hospital. Hedgehog 385 was released weighing 497 g and underwent a steady and statistically significant weight loss during the ensuing three weeks. It may be the case that female hedgehogs weighing less than 500 g in April are not viable. If so, then large numbers must die naturally, as a significant proportion of the population are this size or smaller. In fact, annual mortality among adult hedgehogs is about 30% (Morris 1983), probably concentrated in the early months of the year, so losses among hedgehogs translocated in April must not only be expected, but also accepted as entirely normal.

April must be a challenging time for hedgehogs. Not only is the weather unpredictable, affecting availability of macro invertebrates for food, but this is also the end of the hibernation period. Hedgehogs will have roused from hibernation with their fat reserves depleted. Small animals, especially juveniles from the previous year who entered hibernation weighing perhaps only 450-500 g, will have their reserves practically exhausted; those entering hibernation weighing less than 450 g are unlikely to survive the winter (Morris 1984). Mortality, especially among these yearlings, must be high in natural circumstances. Translocation could add to their problems, but may also alleviate them if the animals are released in better feeding sites. Crucially, releases should not take place in areas where suitable food is naturally scarce (e.g. on acid sandy soils) or during periods of dry weather, especially in habitats liable to dry out quickly (e.g. limestone grassland), restricting food availability.

The policy of killing Uist hedgehogs rather than translocating them to the mainland is based on the principles of density dependent population regulation. In effect this means that the mainland could not support more hedgehogs then it would do so naturally, and any additional animals released into existing populations would result in corresponding mortality as numbers will be readjusted to match the carrying capacity of the habitat. The present study, however, offers no support for this idea. If food resources (for example) were a limiting factor, then none of our animals should have maintained or gained weight, but the majority of them did. Hence the claim that translocation of hedgehogs from problem areas such

as the Uists might involve welfare problems is not justified by the present stud .

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References

Doncaster, P.C. 1994. Factors regulating local variations in abundance: field tests on hedgehogs, *Erinaceus europaeus*. Oikos 69: 182-192.

Fuller, R.J., T.M. Reed, N.E. Buxton, A. Webb, T.D. Williams & M.W. Penkowski 1986. Populations of breeding waders Charadrii and their habitats on the crofting lands of the Outer Hebrides, Scotland. Biological Conservation 37: 333-361.

Jackson, D.B. 2001. Experimental removal of introduced hedgehogs improves nest success in the Western Isles, Scotland. Journal of Applied Ecology 38: 802-812.

Jackson, D.B. & R.E. Green 2000. The importance of the introduced hedgehog (*Erinaceus europaeus*) as a predator of the eggs of waders (Charadrii) on machair in South Uist, Scotland. Biological Conservation 93 (1) 333-348.

Molony, S., V. Dowding, J. Baker, C. Cuthill & S. Harris 2006. The effect of translocation and temporary captivity on wildlife rehabilitation success: An experimental study using European hedgehogs (*Erinaceus europaeus*). Biological Conservation 130 (4): 530-537.

Morris, P.A. 1983. Hedgehogs. Whittet Books, Weybridge, UK.

Morris, P.A. 1984. An estimate of the minimum body weight necessary for hedgehogs (*Erinaceus europaeus*) to survive hibernation. Journal of Zoology, London 203: 291-294.

Morris, P.A. 1988. A study of home range and movements in the hedgehog (*Erinaceus europaeus*). Journal of Zoology, London 214: 433-449.

Morris, P.A. 1997. Released, rehabilitated hedgehogs - a follow-up study in Jersey. Animal Welfare 6: 317-327.

Morris, P.A. 1998. Hedgehog rehabilitation in perspective. Veterinary Record 143: 633-636.

Morris, P.A. & H. Warwick 1994. A study of rehabilitated juvenile hedgehogs after release into the wild. Animal Welfare 3: 163-177.

Morris, P.A., K. Meakin & S. Sharafi 1993. The behaviour and survival of rehabilitated hedgehogs *(Erinaceus europaeus)*. Animal Welfare 2: 53-66.

Reeve, N.J. 1982. The home range of the hedgehog as revealed by a radio tracking study. Symposium of the Zoological Society of London 49: 207-230.

Reeve, N.J. 1998. The survival and welfare of hedgehogs (*Erinaceus europaeus*) after release back into the wild. Animal Welfare 7: 189-202.

Reeve, N.J. & P.A. Morris 1986. Mating strategy in the hedgehog (*Erinaceus europaeus*). Journal of Zoology, London 210: 613-614.

Sainsbury, A.W., A.A. Cunningham, P.A. Morris, J.K. Kirkwood & S.K. Macgregor 1996. Health and welfare of rehabilitated juvenile hedgehogs (*Erinaceus europaeus*) before and after release into the wild. Veterinary Record 138: 61-65.

Uist Wader Project 2002. Three potential methods of reducing the non-native Uist hedgehog population to conserve breeding waders: animal welfare and conservation considerations. UWP, Edinburgh, UK.

Samenvatting

Overleving en veranderingen in lichaamsgewicht van egels (*Erinaceus europaeus*) die zijn overgebracht van de Hebriden naar het vasteland van Schotland

Egels (*Erinaceus europaeus*) worden gedood op de Uist-eilanden in de Hebriden, Schotland, in een poging het broedsucces van grondbroedende vogels te verbeteren. Verplaatsing van de egels is als mogelijkheid overwogen, maar verworpen op basis van aspecten van dierenwelzijn. De belangrijkste zorg was dat de verplaatste dieren zouden verhongeren. Dit onderzoek is gestart om deze hypothese te testen. Twintig egels van de Uist-eilanden zijn losgelaten op het Schotse vasteland in Eglinton Country Park, Irvine, waarna de egels voor de duur van een maand met behulp

van radiotelemetrie zijn gevolgd om te bepalen of de dieren wel of niet verhongeren in hun nieuwe leefomgeving. Zeven van de twintig gezenderde egels laten een significante toename in lichaamsgewicht zien, bij vijf bleef het gewicht min of meer gelijk en drie verloren gewicht. Twee van de egels die gewicht verloren stierven tijdens de studie. Drie egels stierven in een vroeg stadium van het onderzoek door predatie en verdrinking. Eén egel stierf als gevolg van een reeds voor de aanvang van de studie aanwezige tumor. Als deze gestorven egels en het individu dat verdween op de eerste nacht na loslating niet mee worden genomen in de analyse is sprake van 80% overleving één maand na de verplaatsing van de egels. Als alle vroege sterfgevallen als gevolg van predatie en verdrinking worden toegeschreven aan de onbekendheid van de verplaatste egels met het terrein is sprake van 67% overleving één maand na de verplaatsing. De gegevens suggereren dat vrouwelijke egels die meer dan 550 g wegen op het moment van verplaatsing in het voordeel zijn. Hoewel conclusies met enige voorzichtigheid moeten worden getrokken als gevolg van het beperkte aantal gevolgde egels, de relatief korte onderzoeksperiode en de onderzoeksaanpak, suggereert onze studie dat zorgen over het welzijn van verplaatste egels weinig onderbouwd zijn, en er aldus vraagtekens kunnen worden gezet bij het belangrijkste bezwaar om egels van Uist naar het Schotse vasteland te verplaatsen.

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