THE BEHAVIOUR AFTER RELEASE OF CAPTIVE-REARED FOX CUBS

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The release of animals from captivity frequently leads to a period of erratic movement behaviour which is thought to expose the animal to a high risk of mortality. Twenty-six foxes which had been reared at a wildlife hospital or captive-bred, were radio-collared when nearly full-grown and released without site acclimation. Immediately after release there was an erratic phase of behaviour, during which the foxes travelled widely and movement parameters were markedly elevated. For those foxes which survived, a second phase was entered after an average of 17.2 days, during which one small area only was used, and movement parameters were much reduced. In a second study, nine foxes were released following site acclimation in a pre-release pen; this process postponed but did not eliminate the phase of high movement activity.

This pattern of movement was compared with the dispersal behaviour of wild-reared foxes. It was concluded that released foxes, despite being proficient in other aspects of behaviour, were moving and behaving in a markedly abnormal manner and this resulted in a high death rate. The results are used to discuss methods of improving rehabilitation techniques.

Keywords: *animal welfare, dispersal, fox, radio-tracking, rehabilitation, release from captivity*

Introduction

The release of an animal into an unknown environment, whether it involves the translocation of wild animals, reintroduction of captive-bred animals, or the rehabilitation of sick or orphaned animals, frequently produces unnatural behaviour and erratic movements (Bright & Morris 1994). Periods of high movement activity, both by released animals and also among wild animals at the time of dispersal, are generally considered to be associated with high mortality, but demonstrating direct links between the two has so far proved difficult (Macdonald & Voigt 1985). Site acclimation prior to release is generally considered to be beneficial in reducing the risk of abnormal behaviour and/or mortality (Moore & Smith 1991), but is expensive and for some species may be unnecessary (Morris *et al* 1993).

In the previous paper (Robertson & Harris 1995), we presented the results of a tagging study which showed that there was a very high mortality of foxes (*Vulpes vulpes*) released following rearing in captivity. In this paper we examine the movement behaviour of captive-reared foxes immediately following release to determine whether this contributes to the high rate of mortality reported in the tagging study.

The first stage in such a study is to establish what behavioural pattern might be regarded as normal. A captive-reared fox which is released into a novel environment is unlikely to settle immediately and commence normal territorial behaviour. It is more likely to undergo a period of exploratory behaviour. Since most captive-reared foxes are released in the late summer or early autumn, when wild-reared cubs would be about to undergo dispersal, it might be anticipated that 'normal' behaviour following release would be to show behaviour patterns typical of a dispersing fox. Dispersal is generally perceived to be a process by which an animal searches for a new home range in which to settle, and captive-reared foxes have to achieve the same goal in the period following their release.

Previous studies of the behaviour of dispersing foxes (Storm & Montgomery 1975; Zimen 1984; Woollard & Harris 1990; Robertson 1994) have shown that phases of rapid movement behaviour were found to last for a few days only. If dispersal was not completed in this time, it became an episodic process, with rapid movements interspersed by periods spent on a temporary range. Storm and Montgomery (1975) and Zimen (1984) found that the whole process did not exceed 18 days, and movements during successive nights followed a consistent compass bearing. The other two studies reported a series of exploratory trips from the natal range prior to the actual dispersal movement, which frequently took place in the course of a single night, with mean dispersal distances being much shorter than in the other two studies. Thus dispersal-type movements of foxes can be expected to be brief in duration and not disoriented, and this should also be true for released foxes if they are not markedly affected by the release and rehabilitation process.

The aim of this paper is to test the hypothesis that, following release at the onset of the dispersal period, captive-reared fox cubs should undergo brief, non-disoriented dispersal-type movements before settling on a temporary or permanent home range. We also aimed to test the hypothesis that site acclimation is beneficial in reducing the mortality of released foxes.

Methods

Releases without site acclimation

Twenty-six fox cubs (10 males, 16 females) which had been reared in captivity were used for the study. Eighteen (eight males, 10 females) were from a wildlife hospital and eight (two males, six females) were captive-bred and reared in pens with their parents. Further details of the rearing regime at the wildlife hospital and the captive colony are given by Robertson and Harris (1995).

Seventeen of the foxes were released between August and November, during the same period as the previously reported tagging and release study (Robertson & Harris 1995), and nine were released between December and March. Thus all were less than a year old at release and were released during the main natural dispersal period (Harris & Trewhella 1988). Each animal was ear-tagged and fitted with a radio-collar prior to release as described by Harris (1980). Foxes were released singly with the exception of the first two, which were released together. The releases were in the rural parts of the county of Avon; this area is described by Robertson and Harris (1995). Releases were carried out at night, on the same day as the foxes were removed from the wildlife hospital or captive colony, and no site acclimation or aftercare was provided. Animals were released into cover away from busy roads.

The night on which an animal was released was denoted night zero, the following day, day one, the following night, night one, and so on. Individual foxes were tracked on a set timetable, whereby each fox was tracked on night 1 or 2, night 3 or 4, and once between nights 6 and 8, 13 and 15, 19 and 21, 30 and 32, 39 and 43, and 60 and 78. As few foxes were still alive and their positions known after this, intensive tracking was discontinued until four months later, when the two remaining foxes were tracked for three nights each between nights 217 and 251 to obtain final range sizes. It was not possible to track each fox at every occasion dictated by the protocol, because some animals were lost whilst being tracked and could not be relocated until several nights later.

Foxes were tracked individually for eight-hour periods from 2000 to 0400 GMT (Saunders *et al* 1993; White & Harris 1994). Locations (fixes) were taken at ten-minute intervals, and recorded as coordinates quoted to the nearest 50m. Such accuracy was possible because the position of the fox could be related to features such as hedges, ditches, roads and pylons marked on large-scale maps carried in the field, and because most fixes were taken at a range of 200m or less. Tracking was carried out on foot using a hand-held Yagi antenna and receiver (Custom Electronics of Urbana Inc, Illinois, USA), but following movements into new areas, foxes were located again by searches carried out from a vehicle with a whip aerial attached to the roof. Positions at which the foxes rested during the day (lying-up sites) were recorded as often as possible during daylight, and other nocturnal positions outside the main activity period were also occasionally recorded, usually before or after tracking a different fox.

Releases with site acclimation

Two groups of foxes were released following site acclimation in a pen measuring 30x30m and which contained vegetation cover and an artificial underground earth. Group A (2 males, 3 females) were held in this pen for 35 days prior to the door being opened on October 12 1992. Group B (2 males, 2 females) was kept in the pen for 18 days prior to release on December 1 1992. One female in group B originated from the captive-breeding colony; all the others were from the wildlife hospital. Food was provided in the pen for seven days after release. Tracking regimes were the same as those described above, except that a night's tracking was terminated if no movements outside the pen were recorded in the first five hours.

Analysis of the radio-tracking data

Tracking data were analysed for each night individually, and summary data were obtained for the following six behaviour parameters: nightly range area, nightly range length, total distance travelled, average speed of travel, maximum speed of travel and percentage time spent active. The nightly range was defined using the minimum convex polygon method (Harris *et al* 1990). The nightly range area was defined as the area of the polygon enclosed by this process, and the range length was its maximum diameter. Fixes were recorded as active (signal strength fluctuating) or inactive (signal strength constant), and the percentage of fixes which were active was calculated. Speeds of travel were calculated only for those ten-minute periods in which the fox was active for both fixes and where it moved to a different 50m coordinate between the two (ie zero movements were not included). Distance travelled was calculated from the movements between 50m coordinates. For nights where the fox was lost for part of the night, data were only included if at least 33 fixes (ie 5.5 hours out of the total maximum of 8 hours tracking time) had been obtained.

Results

Releases without site acclimation: general description of behaviour and visual observations

Movements of foxes in the period immediately following release were highly variable and erratic, and often involved long-distance, high-speed travel. The foxes covered a very large area at this time both over this whole phase of behaviour, which was termed the erratic phase, and within each night's movements. Several foxes were recorded crossing motorways, and one crossed and re-crossed the mouth of the river Avon in successive nights, swimming across 30m of moving water. Nights where high movement activity was observed included some where the fox concerned dispersed to a new area, and others where the animal returned to the point at which it had been located at the start of the night, thus demonstrating some ability to navigate. However, movements made in successive nights did not follow a consistent compass bearing, and several foxes crossed the trajectory of a previous night's travel.

Twelve animals died during the erratic phase, and six also disappeared and could not be relocated. The erratic phase was sometimes absent altogether, but normally lasted one to five weeks. This was followed by a more settled phase of behaviour, where each animal generally used one area only, although on two occasions foxes made long-distance excursions during the settled phase from areas where they had established, or were in the process of establishing, home ranges.

During the erratic phase foxes were seen hunting for worms on pasture within a few days of release, and they were also seen to locate and scavenge from dustbins, bird tables and a donkey carcass. These observations indicate an ability to find and utilize food sources. Four foxes were seen to interact with wild foxes on several occasions: some of these were friendly, but two were aggressive, with the released fox (a male) being dominant in one and the released fox (a female) submissive in the other. One female appeared to be accepted by the resident fox social group, and remained within a few hundred metres of the release point for 23 days until killed in a road traffic accident.

Several of the released foxes showed a marked tameness, failing to show the same caution as wild foxes in the presence of humans, and even approached to within 2m of the person doing the radio-tracking. This behaviour did not appear to decrease with time: one fox still approached local residents until its death sixteen months after release. Similarly, the released foxes did not avoid roads: several were seen to remain standing in roads as vehicles approached, causing the vehicles to come to a complete stop, or others would attempt to flee from vehicles along the length of roads rather than into the hedgerows at the side. Rehabilitated animals making long-distance movements often used small roads as travel routes, although larger roads with constant traffic were not used in this manner.

Releases without site acclimation: lying-up sites

On day one and thereafter foxes found secure lie-up sites in holes or dense cover such as woodland or brambles. They would also use man-made features such as rubbish tips or piles of timber. The two foxes which were released together lay-up in close proximity in a disused quarry until one was killed by dogs a week after release.

The location of lie-up sites was used to illustrate the gross movements of the animals. For the nine foxes (five males, four females) that were tracked for three weeks or more, the distances of all lie-up sites from the point of release were calculated. Where lie-up sites were

not obtained, locational data taken after dark but before or after the main activity period were used instead, since the foxes were then usually close to the site where they had lain-up the previous day or would lie-up on the subsequent day. These distances were plotted against the number of days elapsed since release; three examples are shown in Figure 1.

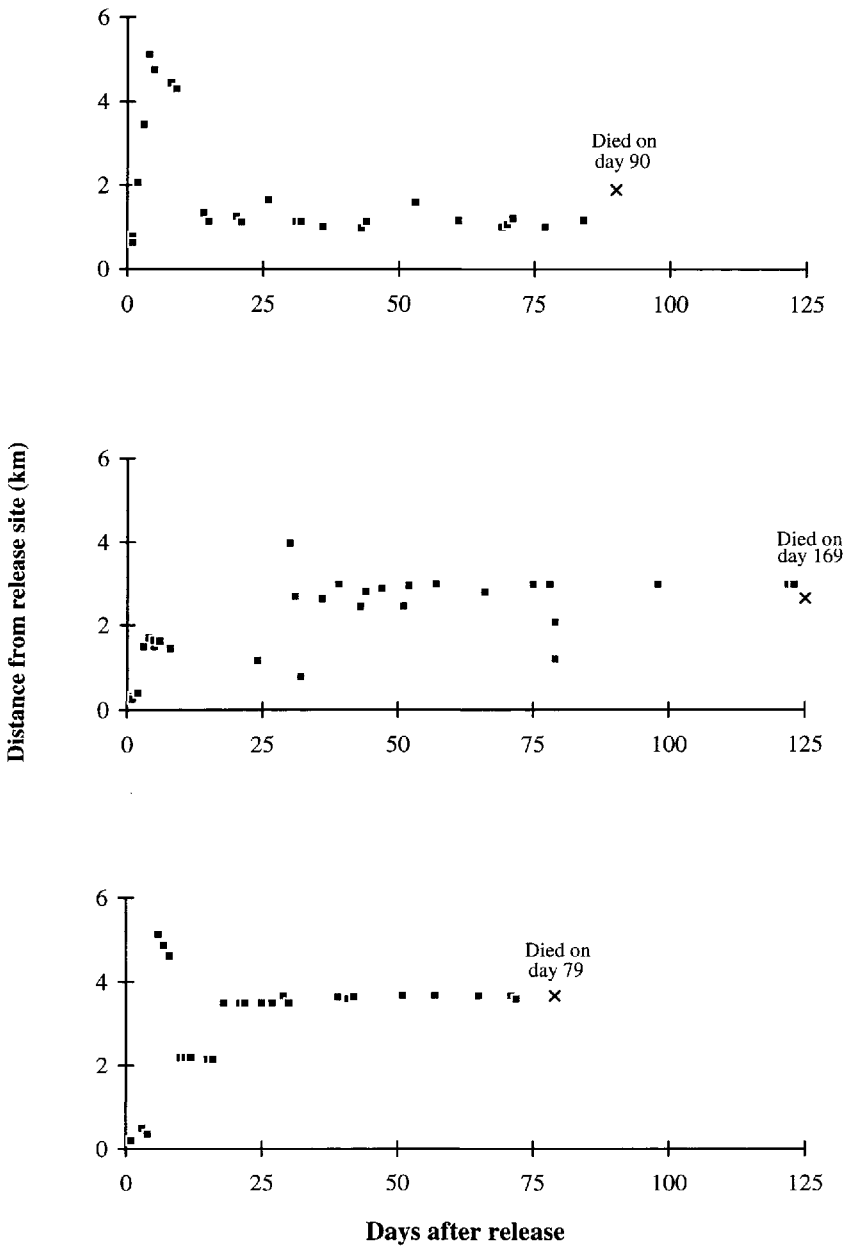

Figure 1 **Distance of lying-up sites from release site, plotted against time in days for three foxes: (top) female 2363; (centre) male 2369; (bottom) female 2527. The crosses denote the location and date of death.**

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The released foxes initially covered a large area, and hence lie-up sites were widely scattered, but would then start using only one area. Hence the erratic and settled phases were defined objectively from these graphs. For those foxes whose survival time was short and which therefore had little time to show settled behaviour, such decisions had to be somewhat subjective. Table 1 gives the time at which each fox was considered to have changed phases. Six out of nine foxes had an obvious erratic phase, which lasted an average of 17.2 days, with a maximum of 35 days. One showed no erratic behaviour, while the remaining two could not be found several times in the first week, when erratic movements may have occurred.

Table 1 **Duration (days since release) at which the erratic phase ended and the settled phase began, as calculated from graphs similar to those shown in Figure 1.**

Fox number and sex	Last recorded night in erratic phase[1]	First recorded night in settled phase[2]
2363-F	35	39
2366-M	-	10
2369-M	9	13
2380-M	10	(52)
2435-M	-	(1)
2446-F	23	-
2527-F	16	18
2530-F	-	8
2531-M	10	14
Mean	17.2	17.0
SEM	4.2	4.6

[1] For the last night in the erratic phase, no data are given for two animals (2366 and 2530) which were lost until they were relocated once they had entered the settled phase, and for one (2435) which showed no erratic phase of behaviour.

[2] Two foxes were excluded when calculating the mean time of entering the settled phase: 2380 because it was lost for six weeks during which the settled phase began, and 2435 because it did not show any erratic behaviour but settled immediately at the release site.

Releases without site acclimation: radio-tracking data

Sixty-two nights of tracking data were obtained from fifteen different foxes. However, only the nine foxes which survived three weeks or more are included in the following analysis. Each night for which tracking data were obtained was allocated to either the erratic or the settled phase of behaviour, as defined above. For each parameter of behaviour an average was calculated for each fox in each phase. There were sufficient data to calculate averages for five of the nine foxes in the erratic phase, and eight of the nine foxes in the settled phase; these are shown in Tables 2 and 3. Five of the six movement parameters were all

significantly greater in the erratic phase but there was no difference for percentage time spent active (Mann-Whitney tests, n = 13: $U_{(area)} = 1.0$, $P < 0.01$; $U_{(length)} = 0.0$, $P < 0.01$; $U_{(distance\ travelled)} = 6.0$, $P < 0.05$; $U_{(average\ speed)} = 3.5$, $P < 0.05$; $U_{(maximum\ speed)} = 5.5$, $P < 0.05$; $U_{(activity)} = 10.5$, $P > 0.1$). There were no apparent differences between sexes for either the length of the erratic phase or for the recorded movement parameters. However, there were insufficient data to test statistically.

Table 2 **Summary of the radio-tracking data for the erratic phase. All figures are per night. Only those animals with at least one night's radio tracking with > 5.5 hours of data are included.**

Fox number and sex	Number of nights' data	Range area (ha)	Range length (m)	Distance travelled (m)	Mean speed (m min^{-1})	Maximum speed (m min^{-1})	Activity (%)
2363-F	4	142.1	2162	5967	18.4	69.5	88
2369-M	3	59.6	1494	4837	14.7	49.4	78
2380-M	4	41.6	1104	5988	16.3	47.9	94
2446-F	4	69.6	1449	3469	17.1	38.6	70
2527-F	1	115.1	2191	5177	23.5	51.5	80
Mean		85.6	1680	5088	18.0	51.4	82
SEM		18.6	214	462	1.5	5.0	4

Table 3 **Summary of the radio-tracking data for the settled phase. All figures are per night. Only those animals with at least one night's radio tracking with > 5.5 hours of data are included.**

Fox number and sex	Number of nights' data	Range area (ha)	Range length (m)	Distance travelled (m)	Mean speed (m min^{-1})	Maximum speed (m min^{-1})	Activity (%)
2363-F	3	8.2	722	2246	12.9	44.2	62
2366-M	9	14.4	565	2253	10.1	28.0	63
2369-M	5	38.0	955	4247	15.0	33.4	82
2380-M	3	14.6	583	5057	16.9	38.5	76
2435-M	5	6.1	381	1991	9.2	22.4	78
2527-F	4	3.4	284	1770	8.7	19.4	71
2530-F	2	48.8	1010	5940	15.8	58.5	83
2531-M	2	14.9	610	3174	10.2	26.2	73
Mean		18.6	639	3335	12.4	33.8	74
SEM		5.7	89	555	1.1	4.6	3

Two male foxes (2366 and 2380) were radio-tracked after the breeding season, by which time they had been at liberty for over six months. These foxes had established home ranges similar in size to those for foxes in nearby urban Bristol (Saunders *et al* 1993). Whilst there were insufficient data for statistical analysis, movement parameters such as range area and length, and distance and speed of travel, were larger than for the first two months of the settled phase (Table 4).

Table 4 **Comparison of the early and late stages of the settled phase of behaviour. All figures are per night. The data for the early part of the settled phase (nights 39–43 and 60–78) were averaged from one night's radio-tracking from each of the same four foxes (two males, two females). The data for the late stages of the settled phase were averaged from three nights radio-tracking from each of two male foxes (2366 and 2380) collected between nights 217–251 post-release.**

	Number of nights' data	Range area (ha)	Range length (m)	Distance travelled (m)	Mean speed (m min^{-1})	Maximum speed (m min^{-1})	Activity (%)
Nights 39-43	4	7.0	361	2171	8.6	36.1	73
SEM		2.0	98	548	1.0	9.8	7
Nights 60-78	4	8.0	605	2166	12.9	35.1	60
SEM		2.8	223	792	2.7	12.1	11
2366-M	3	21.2	978	3252	13.6	48.1	68
SEM		4.6	211	275	1.9	14.2	7
2380-M	3	14.6	574	5057	16.9	38.5	76
SEM		1.3	42	377	0.7	4.2	4

Releases with site acclimation: general description of behaviour

Most of the foxes remained in the vicinity of the pen for the first ten days after the door was opened and ate the supplementary food while this was provided. Some foxes made exploratory trips from the pen and then returned to lie-up, while others lay-up elsewhere but returned to the pen during the course of the night, leaving before dawn. Thus the pen was a focus for activity and social interactions, the foxes spending long periods together there. All foxes whose collars were still working had left the pen by night 12, and some were recorded making dispersal-type movements with high movement parameters; the last night on which data were obtained was night 16 after the release of group B. However, one fox with a non-functional collar was seen outside the pen three months after the last release.

Discussion

Foxes are highly adaptable, with no specialized food or habitat requirements, and these features, coupled with their mobility, are the keys to their success (Lloyd 1980). In view of their adaptability, it was predicted that they should adapt well following release from a rehabilitation centre. It was also predicted that release during a period of heightened mobility for wild-reared animals of the same age class, the dispersal period, should remove the necessity for site acclimation prior to release, and that the released foxes would join that

highly mobile portion of the wild fox population. In theory at least, foxes should be one of the easiest and more successful species handled by British rehabilitation centres.

The results of the study did not fulfil these predictions. There were some ways in which the behaviour during the erratic phases did resemble that of foxes during dispersal. The nightly range sizes were similar to those of foxes tracked in Bristol whilst making extra-territorial trips during the dispersal season, although they exceeded the averages for the dispersal season as a whole (Robertson 1994), and speeds of travel were also similar to those of dispersing foxes (Woollard & Harris 1990). The way in which released foxes used one area for several days before recommencing long-distance movements, mimics the descriptions given by Storm and Montgomery (1975) and Zimen (1984), although wild-reared foxes in Bristol tend to use temporary ranges for much longer periods (Woollard & Harris 1990; Robertson 1994).

Despite these similarities, however, released foxes were clearly both moving and behaving in many ways which were unnatural. The directional characteristics of dispersal were not apparent in rehabilitated foxes, and the deviating course followed by released foxes could in part explain why the recovery distances for released foxes were lower than expected (Robertson & Harris 1995). The erratic phase of behaviour was an extended behavioural pattern compared to dispersal. Storm *et al* (1976) found dispersal lasted for a maximum of 18 days, and Zimen (1984) found that most of the distance travelled was covered in the first week. By contrast, the erratic phase in this study lasted on average 17.2 days, with a maximum of 35 days. This difference was probably because dispersing foxes carried out many exploratory trips prior to finally leaving their natal range (Mulder 1985; Robertson 1994), thereby reducing or even eliminating the need for searching and exploration undertaken by the animal following its final departure from the natal range. Foxes released without site acclimation were unable to undergo this process, and this might account for the length of the erratic phase. The continued attachment to the natal range in the early phases of dispersal also allows wild-reared animals to feed from familiar food patches between energetically expensive exploratory trips (Woollard & Harris 1990), thereby replenishing fat reserves. Since this was not possible for released foxes, this is likely to have made a significant contribution to the weight loss following release (Robertson & Harris 1995).

After the end of the erratic phase the released foxes restricted their activities to one small area which was used intensively. The use of very small areas (ie 1–6ha) following dispersal has also been noted for wild foxes (Storm & Montgomery 1975; Woollard & Harris 1990; Robertson 1994). This presumably allows the animal to become familiar with local food-rich patches, and also secure refuges and travel routes. In the case of the two released foxes that were radio-tracked for an extended period, these small foraging areas were eventually expanded to reach the size of full territories. In a study of wild dispersing foxes in Bristol, these small foraging areas were either abandoned and dispersal movements recommenced or were expanded to form a territory (Robertson 1994), as occurred for the released foxes. It seems that, contrary to general statements made previously (Lloyd 1980; Henry 1986), a fox does not search for a vacant territory as it disperses, but travels rapidly for a few days and then looks for a very small area, possibly in the interstices between local territories, where it establishes a temporary range (Niewold 1980). Only later does the fox attempt to find or establish a territory of its own. It would appear that a similar strategy is being adopted by released foxes.

If wild foxes benefit from continued attachment to the natal range, then site acclimation, which mimics this attachment, should produce more normal behaviour. As predicted, the animals in this study did mimic the behaviour of wild foxes by returning to the release pen after making forays. During the time spent at the release pen, they consumed the supplementary food and also interacted socially with the other animals from the release group. The subsequent movement from the release site was unexpected, especially for the females, as animals given site acclimation generally do not disperse (Bright & Morris 1994; Robertson 1994), and the rate of dispersal among wild-reared females is generally lower than for males (Harris & Trewhella 1988; Allen & Sargeant 1993).

Although the foxes left the release site, it is probable that site acclimation still conferred several benefits, in particular by learning safe travel routes and foraging areas during their forays. This would reduce the likelihood that they would experience the nutritional stress reported by Robertson and Harris (1995). Since foxes released without site acclimation were able to forage well both by hunting and scavenging, the weight loss reported by Robertson and Harris (1995) would appear to be due to the energy costs of the erratic movements and a lack of knowledge of local food patches rather than an inability to forage.

The high mortality rate reported by Robertson and Harris (1995) is probably also a consequence of the period of erratic movements. During this period the released foxes crossed many more roads than they would normally do during foraging movements on an established home range, and also crossed unfamiliar areas where safe travel routes were unknown. Naïvety to the dangers of vehicles and a tendency to travel along roads enhanced the risk of mortality.

The use of a pre-release pen, in which the cubs were held for a period and at which they were subsequently provisioned for a period post-release, appeared to modify movement behaviour without actually eliminating the erratic phase, and so was likely to produce at least some improvement in survival. Reasons for this can be seen in the behaviour of wild-reared fox cubs. They adopt a movement strategy where, throughout the summer and up to dispersal, the nightly activity is centred on safe refuges and only a small portion of their parent's territory is used. During the summer their range size slowly increases, but even at the onset of dispersal nightly ranges are still smaller than those of their parents (Robertson & Harris unpublished data). This strategy appears to allow them to learn safe travel routes and key foraging areas, and also to slowly develop navigational skills, whilst at the same time exposing them to minimum risks. Even so, mortality is high during this learning period (23.3 per cent, Robertson & Harris 1995), and most die in road traffic accidents (70 per cent) or as a result of other misadventures during this exploratory behaviour.

Animal welfare implications

This study highlights the problems of releasing captive-reared animals. Release procedures that involve no site acclimation, or the use of only short-term pre-release pens, do not give the foxes the opportunity to develop survival skills, something which they do in the wild over an extended period. It is not surprising therefore that the release of captive-reared cubs is problematical. The results of this study and that reported by Robertson and Harris (1995) suggest that cubs should be reared in small groups at the release site, with only one group per site. Rearing should be undertaken in a pen containing cover and an artificial earth. The pen should be opened some time around mid to late June, depending on the age of the cubs,

but they should be provisioned in the pen until the end of the summer. This will allow the cubs to use the pen as a secure site from which to develop their movement, navigational and foraging skills. There will, of necessity, be some mortality during this learning process, but this is likely to be comparable to that recorded for wild-reared fox cubs.

Clearly, this is a very demanding regime for most wildlife hospitals, and with the current number of cubs being captive-reared it will not be practical. However, with the improvements recommended by Robertson and Harris (1995), where most cubs are returned to the point at which they were collected and others are provisioned at their natal earth, the number of cubs being handled will be substantially reduced. Then more labour-intensive release procedures can be used that will enhance the survival of captive-reared fox cubs.

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