THE CONDITION AND SURVIVAL AFTER RELEASE OF CAPTIVE-REARED FOX CUBS

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Abstract

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In Britain large numbers of animals are taken into captivity for treatment or care and then subsequently returned to the wild, but there are few data on the effectiveness of these rehabilitation programmes. In this study, over a period of four years 251 fox cubs that had been captive-reared were tagged and released; 90 were recovered. Survival rates were low, and road traffic accidents were found to be a major cause of mortality immediately following release. Recovery distances were lower than expected. The stress associated with captive-rearing meant that released foxes weighed less than wild-reared foxes, and they suffered further weight loss in the period immediately following release, even though an analysis of the stomach contents of animals recovered dead showed that released foxes rapidly learnt to hunt successfully.

It was concluded that captive-rearing is a problematic process for foxes, and contrary to predictions they face severe problems in adapting following release. Suggestions are made for the improvement of fox captive-rearing and release programmes, and the need for similar studies on other species is highlighted.

Keywords: *animal welfare, condition, fox, rehabilitation, release from captivity, survival*

Introduction

In Britain over the last decade there has been a growing interest in captive-rearing and releasing injured or orphaned wildlife, which largely has been fostered by the formation of the British Wildlife Rehabilitation Council in 1987. Currently there are thought to be about a thousand rehabilitation centres ranging in size from individuals handling just a few animals to large organizations which receive over 10,000 casualties a year. At least 250,000 animals are thought to be received at these centres each year (Harris unpublished data).

Despite the number of animals being treated and released by wildlife hospitals, the effectiveness of these rehabilitation programmes has been little studied (Morris *et al* 1993), and so there are few general guidelines or principles for rehabilitators to follow. One way to address this problem is to study the behaviour of selected indicator species following release. A species that in theory should show a high success rate in rehabilitation programmes is the red fox (*Vulpes vulpes*). It is a highly adaptable and successful carnivore whose mobility and lack of specialized food and habitat requirements allow it to exploit a wide variety of habitats, covering a large geographic range (Lloyd 1980).

However, early translocation studies have not tended to support the hypothesis that foxes should be easy to rehabilitate. A re-analysis of the data presented in Marcström (1968) shows that translocated foxes had a shorter life expectancy than control animals (Mann-Whitney test, U = 16.5, n = 40, $P < 0.05$). Translocated fox cubs between two and four-months-old had very low survival rates (Errington & Berry 1937), which perhaps is not surprising for animals that were so young. The foxes translocated by Andrews *et al* (1973) had survival rates similar to controls, although there was a faster rate of tag returns for animals which had been reared in captivity.

Foxes do not, therefore, seem to be able to survive well following translocation. Whether this also applies to animals that have been captive-reared and released is unclear. In this paper therefore we examine the survival and condition of captive-reared foxes, and in the following paper (Robertson & Harris 1995) we describe their behaviour after release.

Methods

Origin and rearing of the fox cubs

Most fox cubs were reared at a wildlife hospital: approximately 5 per cent were less than 4 weeks-old and required bottle feeding; 85 per cent were 4–12 weeks old, at which age in the wild they would be taking solid food but still be heavily dependant on their parents for provisioning; and the remaining 10 per cent were more than 12-weeks-old. Cubs less than 4-weeks-old were reared on artificial dog milk (Sherley's 'Lactol', CIBA Animal Health, Whittlesford); older animals were fed on defrosted day-old chicks and tripe.

Cubs were housed indoors until six-weeks-old. They were then transferred to an outdoor enclosure measuring approximately 18x18m with a concrete floor and surrounded by block walls 2m high. On average 30 cubs were held together in this pen. From late May onwards, the largest cubs were caught and transferred to pens measuring 30x30m with a grass floor and surrounded by a mesh fence 2m high. Approximately 15 animals were held in each of these pens; all foxes spent some time in these larger pens prior to release.

In addition, some cubs were bred in a captive colony and reared with their parents. Each family group was held in adjacent pens measuring 10x40m (Hartley *et al* 1994).

Release procedures

Releases were undertaken in the late summer or early autumn of 1989–1992. The earliest release date was July 31, and the latest date of a large-scale release was October 6, although a few animals were released individually after this date. Thus most foxes were 4–7 months old (mode = 5.5 months) and were released just prior to or at the start of the main natural dispersal period, which begins in September (Woollard & Harris 1990).

On the day of release, the foxes were ear-tagged in each ear with a white plastic Rototag (Dalton Supplies Ltd, Nettlebed, Henley-on-Thames); these tags were numbered on one side and embossed 'Bristol University' on the other. The cubs were then weighed to the nearest 0.1kg, sexed and placed in release cages holding one to five animals (mode = 4). They were released that night, usually in groups of four, at release sites situated away from main roads. As far as possible foxes were released into vegetation cover. The release protocol was that in use at the time by a large number of wildlife hospitals, and there was no site acclimation or aftercare (Moore & Smith 1991).

Release sites were 1–10km outside the city of Bristol in the county of Avon (51°N 3°W). The pattern of farming in the area is principally pastoral. A proportion of the land is devoted to forestry and shooting estates; gamekeepers operate on these and many of the farms. Using data from Harris *et al* (1995) and Bunce *et al* (1981), fox population density in the release area was estimated to be around 2.75 adults km^{-2}.

Recovery and analysis

Dead tagged foxes were routinely reported to Bristol University, and cadavers or at least tags collected wherever possible. The survival time, recovery distance (direct line distance from release to recovery points), and cause of death were recorded. Whenever possible post-mortem analyses were carried out, where entire and eviscerated weights were recorded to the nearest 0.1kg, the amount of omental and abdominal fat scored separately on a scale of 0–5, the volume of the stomach contents scored on a 0–5 scale, and the abundance of individual food items recorded on a volumetric scale of 1–5 (Harris 1981; Saunders *et al* 1993). For females over ten months of age, the reproductive tract and nipples were examined for evidence of breeding. Finally the probable cause of death was determined where it was not already known.

For comparative purposes, data on wild foxes living in the city of Bristol are used; these were from the same data set, now enlarged, as that described and analysed by Harris and Trewhella (1988). Whilst the data for the Bristol population were not from exactly the same area or habitat in which the cubs were released, they are from the same county and are the most comprehensive set of data available for a British fox population. Also, the demographic and morphometric data used in the analyses presented here are similar to those collected from other fox populations in Britain, and so were suitable for the general comparisons made in this paper.

The survival of fox cubs not taken into captivity

The hypothesis that many of the fox cubs taken into captivity were in fact not orphaned but simply temporarily lost or disoriented was tested. Between March and June fox cubs in Bristol which were reported to be orphaned and which, under normal circumstances, would have been taken to a wildlife hospital for captive-rearing, were ear-tagged as described for the captive-reared cubs and released the following night at the exact point at which they were found. Releases were made after midnight, and the area searched the next day to see if the cub was still in the area of the release.

Results

Recovery of captive-reared animals

Two hundred and fifty-one foxes (136 males, 115 females; 224 from the wildlife hospital, 27 from the captive breeding colony) under one-year of age were released and 90 (47 males, 43 females) recovered ie 35.5 per cent. Since life expectancy for free-living foxes is up to nine years (Harris & Smith 1987), there may be further recoveries of the released foxes. No differences were detected between the animals from the wildlife hospital and those from the captive-breeding colony, and so the data were combined for the following analyses.

Weight on release

To test for differences in weight between wild and released foxes, month (August, September and October) and origin (wild or released) were used as the independent variables in two-way ANOVAs; separate tests were carried out for each sex. There were insufficient data from foxes released in July and November. Released foxes of both sexes were lighter than wild foxes of the same age from urban Bristol (Table 1), this being most pronounced in males ($F_{(males)}$ = 20.82, *df* = 3, 1, 227, $P<0.001$; $F_{(females)}$ = 6.68, *df* = 3, 1, 170, $P<0.05$).

Table 1 Weights (kg ± SEM) of released and wild foxes. Sample sizes are given in brackets.

	August	September	October
Released males	4.5±0.1 (57)	4.6±0.1 (42)	5.0±0.2 (21)
Wild males	4.9±0.2 (32)	5.2±0.1 (28)	5.8±0.2 (33)
Released females	3.9±0.1 (47)	4.3±0.1 (32)	4.7±0.1 (18)
Wild females	4.0±0.1 (33)	4.6±0.1 (14)	5.0±0.2 (14)

It was first observed that some of the released foxes were underweight mid-way through the study, and thereafter the amount of food given to the foxes was increased. The effect this had on the weights of the foxes was analysed using a three-way ANOVA, with half of the study (those in the second half had more food than those in the first half), month and sex being used as the independent variables. Foxes released in the second half of the study were significantly heavier than those in the first, and there was no interaction between sex and the half of the study ($F_{(half\ of\ study)}$ = 1.69, *df* = 1, 2, 1, 216, $P<0.05$; $F_{(interaction)}$ = 0.89, *df* = 2, 216, $P>0.1$). Foxes released in the second half of the study, after the increase in feeding, were then compared with wild foxes using month and origin as independent variables in two-way ANOVAs, and carrying out separate tests for each sex. Following the increase in food supply, released male foxes were still underweight, but the difference for females was not significant ($F_{(males)}$ = 15.17, *df* = 2, 1, 144, $P<0.001$; $F_{(females)}$ = 0.27, *df* = 2, 1, 110, $P>0.1$).

Survival of released foxes

Survival times for each sex are shown in Table 2. There was no difference in survival times for males and females, and the data were therefore pooled for further analysis (Mann-Whitney test, *U* = 830.5, n = 88, $P>0.1$). There was no difference in survival time between animals released before and after September 1, the approximate median release date (Mann-Whitney test, *U* = 871.5, n = 88, $P>0.1$). There was no relationship between mass at time of release and survival time for either sex (Spearman's rank correlation, $r_{(males)}$ = -0.22, n = 47, $P>0.05$; $r_{(females)}$ = -0.21, n = 41, $P>0.05$).

Table 2 **Survival times in days for released foxes.**

	Mean ± SEM	Median	Minimum	Maximum	n
Males	113 ± 30	39	0	1201	47
Females	73 ± 18	19	0	483	41
All animals	94 ± 18	31	0	1201	88

The numbers of foxes recovered dead in each of seven time periods are given in Table 3. For comparison, the mortality rates of wild foxes in their first year, surviving similar time periods, were calculated using data from the Bristol fox population; only animals tagged prior to and recovered after September 1 were included, and September 1 was taken as the equivalent of the release date. Comparing these seven time periods, mortality rates for released foxes declined significantly with time after release (Spearman's rank correlation, r = -0.89, n = 6, $P < 0.01$), showing that survival skills improved with time. However, mortality rates were still higher than for wild foxes in Bristol during every time period, even long after release, suggesting that released foxes were always at a disadvantage compared to wild-reared cubs.

Table 3 **Number of foxes dying in each time period.**

	Number of foxes dying in each time period		Mortality rate (% dying per week)	
	Released foxes	Wild foxes	Released foxes	Wild foxes
Week 1	21	5	24	1
Week 2	12	14	18	4
Weeks 3-4	10	20	10	3
Weeks 5-8	13	40	8	3
Weeks 9-16	8	39	4	2
Weeks 17-26	13	21	8	1
Weeks 27+	11	214	-	-
Date of death unknown	2	-		
Total	90	353		

Weeks indicate the time elapsed since release for captive-reared foxes and since September 1 for wild foxes.

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Weight and condition on recovery

The difference in weight between release and recovery was calculated for each fox. Figure 1 shows these data plotted for the same seven time periods. Comparing the weights of the foxes at the times of release and recovery using paired-sample *t*-tests showed that foxes recovered in the first two weeks were significantly lighter than when released (t = 2.7, n = 13, $P < 0.05$), while there was no difference for foxes recovered in weeks three to eight (t = 1.7, n = 12, $P > 0.1$) or after week eight (t = 1.7, n = 15, $P > 0.1$).

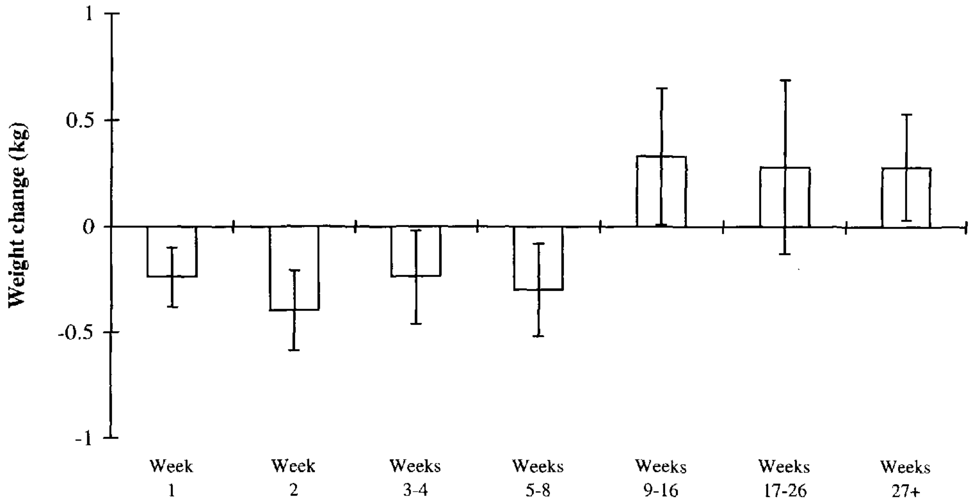

Figure 1 **Change in weight (kg) between release and recovery. The figures are means ± SEM; the sample sizes for each period are 9, 4, 7, 5, 4, 5 and 6 respectively.**

Fat levels for cadavers recovered from August to December were compared with those of first year foxes in Bristol recovered in the same months. Released foxes had significantly lower fat levels than wild animals (Mann-Whitney test, U = 408.0, n = 92, $P < 0.001$). Examining each month individually, fat levels were lower for released animals in all months, but only significantly so in August and September (Mann-Whitney tests, $U_{(\text{August})}$ = 20.5, n = 27, $P < 0.01$; $U_{(\text{September})}$ = 7.0, n = 19, $P < 0.01$; $U_{(\text{October})}$ = 37.0, n = 24, $P > 0.1$; $U_{(\text{November})}$ = 36.0, n = 25, $P > 0.1$); there were insufficient data for December.

Recovery distance

Summary data on recovery distances are given in Table 4. Mean recovery distances were calculated for males and females separately and combined. The mean recovery distance for animals recovered after day 14 was also calculated, as recovery distances before day 14 were biased by some animals being killed close to their release points in the first few days (Figure 2). For comparison, recovery distance (the distance from point of capture to the point of death) and dispersal distance (recovery distances calculated only for foxes which left their natal ranges) are also presented in Table 4 for Bristol foxes. Predicted mean dispersal distances for rural Avon were calculated from algorithms given by Trewhella *et al* (1988): these distances were 4.8km for males and 1.7km for females.

Table 4 **Recovery distances for released foxes and recovery and dispersal distances for Bristol foxes. All figures are in kilometres.**

	Mean ± SEM	Minimum	Maximum	n
Released foxes				
All recovery distances				
Males	2.0±0.4	0.1	9.7	46
Females	2.3±0.4	0.1	11.9	42
All animals	2.1±0.2	0.1	11.9	88
Recovery distances after 14 days				
All animals	2.6±0.4	0.1	11.9	54
Bristol foxes				
Recovery distances				
Males	2.2±0.2	0	18.0	139
Females	0.8±0.1	0	4.1	156
Dispersal distances				
Males	2.7±0.2	0.7	18.0	105
Females	1.6±0.1	0.7	4.1	59

The data from Bristol are for animals tagged as cubs (ie when less than six-months-old) and recovered as adults (ie when over a year-old); see Harris and Trewhella (1988) for details.

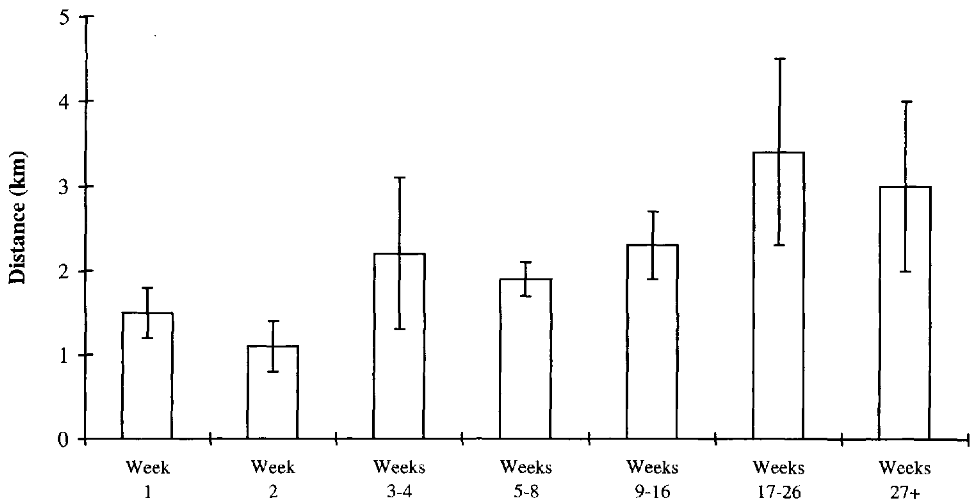

Figure 2 **Recovery distances (km) for seven time periods following release. The figures are means ± SEM; the sample sizes for each period are 20, 12, 10, 12, 8, 13 and 11 respectively.**

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For released foxes, there was no difference in the recovery distance for males and females (Mann-Whitney test, U = 830.5, n = 88, $P > 0.1$), and so the data were pooled for further analysis. Recovery distances of released foxes and dispersal distances of wild foxes were not compared statistically since the types of movement were not directly comparable, and so were only used as an indication of the sort of distances released foxes might be expected to travel before settling on a territory. The mean recovery distance for released male foxes was smaller than the mean dispersal distance observed for males from Bristol and predicted for rural Avon. Conversely, recovery distances for female cubs were slightly higher than the equivalent figures for wild females.

There was a weak but significant relationship between recovery distance and survival time (Spearman's rank correlation, r = 0.27, n = 86, $P < 0.01$). However, this appeared to be largely attributable to short recovery distances obtained in the first few days after release; when all recoveries prior to day 14 were excluded, there was no such relationship (r = 0.02, n = 54, $P > 0.1$). Mean recovery distances for seven time periods post-release are shown in Figure 2; there were no significant differences between these periods (Kruskal-Wallis test, X^2 = 10.1, n = 86, $P > 0.1$), probably due to the small sample sizes in the latter time periods. When time periods were combined into two, recovery distances in the first two weeks were smaller than those for animals recovered later (Mann-Whitney test, U = 532, n = 86, $P < 0.01$).

There was no relationship between recovery distance and mass at release for either sex (Spearman's rank correlation, $r_{(males)}$ = 0.03, n = 46, $P > 0.1$; $r_{(females)}$ = -0.09, n = 42, $P > 0.1$). There was still no relationship when animals recovered in the first two weeks were removed from the data set ($r_{(males)}$ = 0.06, n = 31, $P > 0.1$; $r_{(females)}$ = 0.09, n = 23, $P > 0.1$).

Causes of death

The numbers and percentages of foxes dying from different causes are given in Table 5. Many of the deaths in the weeks immediately following release were from road traffic accidents, but when comparing survival times for animals killed by road traffic accidents, shot, dug out/killed with dogs, and disease, there were no significant differences (Kruskal-Wallis test, X^2 = 6.0, n = 69, $P > 0.1$). However, a comparison of survival times for foxes killed in road traffic accidents with those dying from the other known causes of death combined, showed that animals dying in road traffic accidents had lower survival times (Mann-Whitney test, U = 317, n = 69, $P < 0.05$), suggesting that rehabilitated foxes were particularly prone to road accidents in the period immediately following release.

Table 5 Causes of death for released foxes.

Cause	Number of foxes	Percentage
Road traffic accidents	49	55
Shot	10	11
Dug out/killed with dogs	8	9
Disease	2	2
Other/unknown	20	22

Stomach contents

Stomachs contained a range of food items, and some foxes recovered even in the first week had predated birds, field voles (*Microtus agrestis*), hares (*Lepus europaeus*) and rabbits (*Oryctolagus cuniculus*). Using the seven time periods shown in Table 3 to see if diet and foraging ability changed with time, there was no significant difference in the scores for diet diversity (Kruskal-Wallis test, X^2 = 10.5, n = 53, $P > 0.1$), but there was a difference between scores for the volume of the stomach contents (X^2 = 13.8, n = 53, $P < 0.5$). However, this was because a high proportion (five out of seven) of the animals killed from week 27 onwards had empty stomachs; this was thought to be random variation. When the animals killed from week 27 onwards were excluded, there was no significant difference (Kruskal-Wallis test, X^2 = 6.4, n = 46, $P > 0.1$). Thus the variations in the weight and fat data cannot be explained by an inability to forage immediately following release.

Evidence of breeding

Reproductive data were obtained for five vixens. Three, all killed in their second summer, had placental scars and distended nipples, indicating that they had given birth and lactated. One animal killed in its first summer had no placental scars and had therefore not bred. The remaining vixen, killed in March when vixens of breeding status would normally be heavily pregnant, was anoestrus.

The survival of fox cubs not taken into captivity

Sixty-one reputedly orphaned fox cubs were tagged and released at the point where they were found. Three (5%) were recovered shortly afterwards in poor condition. These were assumed to have been genuinely orphaned and were then taken into captivity; the remaining 58 were believed to have rejoined their family group. Of these, 23 (40%) were subsequently recovered (2 recaptured, 21 dead). The mean survival times for the 21 recovered dead were 463 ± 108 days for males (n = 11) and 469 ± 224 days for females (n = 10). Including the age of the cubs when they were tagged gave a mean age at death of 17.7 months for males, 17.8 months for females, almost identical to the mean ages of death of 16.6 months for males and 17.8 months for females calculated by Harris and Smith (1987) from post-mortem samples from the same population.

Discussion

Early experiences trying to reintroduce captive-bred species to the wild have made conservationists increasingly aware that the chances of success are greatly enhanced by pre-release training (Price 1989; Box 1991). However, conservation reintroduction programmes are specialized projects that usually handle only a small number of individuals of an endangered species. In comparison, wildlife rehabilitators usually receive large numbers of animals of different species and ages that spend variable lengths of time in captivity. Under such circumstances it is rarely possible to spend long periods on pre-release training. So instead the general advice is to release animals as soon as possible (eg Harris 1989), although orphaned animals are likely to spend a longer than average period in captivity.

In view of the behavioural plasticity of the red fox, we anticipated that orphaned cubs should survive well following release from a wildlife hospital. Some predictions were born out: despite an extended period in captivity in which there was very limited opportunity to develop hunting skills, most animals were able to hunt large and unfamiliar prey almost immediately following release; and there was no evidence that the diversity of food items in the stomach, or the volume of stomach contents, were reduced compared to wild-reared foxes at the same time of the year. These data would suggest that hunting was a skill that was either innate or learnt quickly, and that pre-release training to develop hunting skills was not necessary for foxes.

However, clearly there are aspects of captive-rearing that led to stress-related problems, particularly for male cubs, and the most obvious expression of this was their low weight prior to release, particularly in the first half of the study. One explanation could be that the released foxes were not actually underweight, but that the urban foxes with which they were compared were atypically large. However, the weights of adult foxes from Bristol (Saunders *et al* 1993) are similar to, and even slightly smaller than, those given by Hattingh (1956) for other parts of the country, and so this hypothesis is unlikely to be correct.

The amount of food provided for captive cubs was estimated on a per capita basis at several feeding points within the pens to try to prevent a few animals monopolizing the food supply. Yet despite best endeavours, it was likely that competition for food was high; even though enough food was provided per capita, it may have been unevenly shared. However, the amount of food supplied was not the principal factor leading to reduced growth; following an increase in food supply half-way through the study the male cubs were still underweight, although this was no longer the case for the female cubs.

The most probable explanation for the foxes being underweight is the stress associated with captivity and social interactions with an unnaturally high number of conspecifics. Captivity has been shown to raise the levels of the hormones associated with stress in foxes (Keeler *et al* 1968; Hartley *et al* 1994), and crowding is known to raise levels of adrenal hormones in mice (Christian 1971). High levels of adrenal hormones are known to affect metabolism and thus growth (Turner 1968). Since the work of Macdonald (1980) suggests that male foxes are less sociable than females, males would be expected to show more stress-related effects than females, as was observed in this study.

There is clearly a problem for a wildlife hospital trying to handle large numbers of orphaned cubs, and one possible way to resolve this might be to hold the cubs in smaller groups mimicking wild litters. In addition, these groups should consist of individuals of the same age to reduce the chances of older animal(s) monopolizing all the food resources. However, this is unlikely to resolve the problem if the groups are still in visual, auditory and/or olfactory contact. The captive-bred cubs used in this study still showed high levels of stress, social suppression of reproduction, and reduced cub growth even though they were reared as individual litters with their parents (Hartley *et al* 1994; Robertson & Harris unpublished data). For this colony, the pens were adjacent but with visual barriers separating the animals. For a captive-breeding colony in Australia the foxes were held in pens of similar size but spatially separated. Despite the physical separation, the foxes were still in social contact, still showed social suppression of reproduction (A Newsome personal communication 1994), and therefore were presumably still experiencing similar levels of stress. Providing the degree of isolation and size of pen that may be required to reduce significantly the level of stress associated with captivity, is likely to be beyond the scope of most wildlife hospitals.

The consequences, if any, of releasing foxes which are underweight remain unknown. Survival time was independent of weight, and some of the smallest foxes were among the long-term survivors. It is possible that such animals would have difficulty in establishing a territory and/or joining the breeding population, as their smaller size would make them less able to compete in aggressive encounters with conspecifics. However, three out of five vixens recovered after their first breeding season had reared cubs, a comparable proportion to first-year wild-reared foxes (Harris & Smith 1987). Thus released female cubs that survived were able to integrate into the breeding population; whether the same applies for males is less clear because the effects of stress were more marked than for females. We have insufficient data on condition from long-term survivors, but the findings of Lindström (1981) that foxes which were undersized at the end of their first year had reached normal size by the end of their second, suggest that released foxes may recoup lost growth.

The distances travelled by the foxes following release did not conform with predictions. Both released and dispersing animals must find an area to establish a home range, although this may subsequently be abandoned (Woollard & Harris 1990). Release of animals, especially where site acclimation is not used, frequently causes them to undergo a phase of erratic wandering (Bright & Morris 1994), and this would also have been expected to increase recovery distances above those for wild animals. However, recovery distances for male, but not female, released cubs were lower than estimated dispersal distances for wild fox cubs in Avon. From previous work on wild foxes (Harris & Trewhella 1988; Allen & Sargeant 1993), it was also predicted that males would have greater recovery distances than females, but this was not the case. The weight of females was less affected by captive-rearing than that of males; female recovery distances were also close to predicted female dispersal distances for Avon, whereas male recovery distances were considerably less than expected. Thus whilst reduced size in the males may not affect survival, it may affect locomotor activity.

Whilst some reduced survival was expected for released foxes, the markedly lower survival rates when compared to urban foxes, particularly in the weeks immediately following release, were not predicted. To some extent this difference was an artefact of the comparisons being made. For the released foxes, long-distance dispersal-type movements would have occurred in a concentrated burst following release, whereas only half of the foxes in the comparison population dispersed in their first year (Harris & Smith 1987). Thus lower survival in the first few weeks following release was to be expected. The other factor to consider is that many wild-reared cubs die during the summer; of 374 cubs marked in Bristol before the start of May (the peak period for the arrival of cubs at the animal hospital) and subsequently recovered dead, 87 (23.3%) died before September 1. Very few cubs died in captivity during the same period; of the 255 cubs received at the wildlife hospital during this study, only 4 (1.6%) died in the hospital (excluding animals that were sick or injured on arrival). So a period of heightened mortality following release is to some extent offset by the reduced mortality rates whilst in captivity.

Thus, although an adaptable species was chosen for this study, a number of problems were apparent. In particular, the study highlights the danger of assuming that animals reared in captivity will be able to adapt following release, and underlines the importance of analysing survival in all large-scale rehabilitation programmes. Comparative data are needed to see if the problem is more acute for less adaptable and/or more specialized species.

Animal welfare implications

This study suggests that the general admittance procedures adopted by wildlife hospitals need to be reassessed. Harris and Macdonald (1987) argued that 'orphaned' cubs should be returned to the point at which they were found, and in the majority of cases the cubs will be found and reared by their parents. This was confirmed by the results reported above from the study in Bristol. In addition entire litters of cubs that are orphaned after weaning can be reared *in situ* by provisioning near the den (Harris & Macdonald 1987; Stocker 1994). It is even possible to introduce fox cubs into unrelated litters for adoption (Andrews *et al* 1973).

The adoption of these alternative approaches will greatly reduce the number of animals that are reared at wildlife hospitals. The experience at Bristol showed that only 3/61 cubs that would normally have been taken into captivity were genuinely orphaned; the other 95% were only temporarily separated from the rest of the litter. Thus there is considerable scope to reduce the number of fox cubs taken to wildlife hospitals. Fewer animals will reduce the stress associated with the presence of many animals in sensory contact, and also ensure that greater provisioning can be made for each individual during the release process. Such a change in strategy will enhance the survival of the foxes, but requires an educational programme to deter people from bringing young foxes into captivity.

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