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# The welfare of farmed foxes *Vulpes vulpes* and *Alopex lagopus* in relation to housing and management: a review.

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**Abstract**

*Foxes have been kept in captivity in Europe for the purpose of fur production for 70-80 years. In comparison with the main domesticated animal species, this is a very recent intervention. This paper reviews available evidence concerning the welfare of farmed foxes in relation to housing and management. The bulk of the literature relates to early handling of cubs, with the intention of reducing their subsequent fear of humans, and to simple changes in the cage environment that may provide environmental enrichment for foxes. Fear of humans appears to be a significant and pervasive problem, and the barrenness of cages is also a cause for concern. The extent of abnormal behaviours and reproductive failure, both indicative of quite severe welfare problems, is not sufficiently documented. Some housing and management practices are less detrimental than others, nonetheless, the evidence suggests that the welfare of farmed foxes is poor.*

**Key words:** *animal welfare, housing, management, foxes, fear, enrichment, reproduction*

## Introduction

There are two fox species involved in fur production on farms: the silver fox, a colour variety of the common red fox *(Vulpes vulpes)* and the blue fox, a variety of the Arctic fox *(Alopex lagopus)* (Burton 1979, Bakken *et al* 1994). The first silver foxes and blue foxes were kept on farms 80 and 70 years ago respectively but they have been kept in numbers on fur farms for approximately 50 years. Thus, the question of whether or not they could be said to be domesticated arises and this is relevant to the likelihood of good welfare under farm conditions. In comparison with species such as sheep, cattle, horses, dogs or llamas, which have been kept in captivity for more than 5000 years (Hemmer

1983), the foxes have had only very recent contact with humans. Chromosome mapping of dogs and red foxes shows that they have many similarities but that the red fox is more like the ancestral carnivore type and that the dog or wolf karyotype has changed in many ways because of chromosomal fusion and fission events (Yang et al 1999). Almost all farmed foxes live in wire cages with very limited human contact. As Price (1997) has emphasised, domestication implies adaptation by genetic change occurring over generations, in addition to environmentally-induced changes during the development of individuals, so the foxes have had little opportunity to become domesticated. The level of adaptation reached by the main domestic animal species, which are relatively small in number, indicates that the vast majority of individuals have the ability to breed with no problems and most can tolerate some physical contact and prolonged human close proximity with no substantial emergency physiological or behavioural responses. The domestic animals still have a full range of needs, including those to show certain behaviours (Broom and Johnson 1993), but these can be satisfied in appropriately designed captive environments and with appropriate management. The extent to which fear can be reduced by experience of human contact is reviewed in this paper but have the foxes the capacity to adapt fully to farm conditions and hence can their welfare be good on farms?

This paper reviews available evidence concerning the welfare of farmed foxes in relation to housing and management. For background, it begins with an overview of housing conditions on farms and the biology of foxes in the wild. A more general, earlier review (Bakken *et al* 1994) concluded that the major welfare problems on fox fur farms are: a widespread and apparently considerable fear of humans; the barrenness of cages; and difficulties in reproduction. Bakken *et al* (1994) conceded that public criticism of these aspects of fox farms was entirely justified. The greater part of this review, therefore, focuses on evidence related to these issues.

The welfare of fur animals is the subject of some recommendations and codes of practice produced by government agencies or by the industry. The most comprehensive of these is the "Recommendation Concerning Fur Animals" produced in 1999 by the Council

of Europe Standing Committee of the European Convention for the Protection of Animals Kept for Farming Purposes. However, since these are not scientific publications they are not quoted in this review.

**The conditions on fur farms**

Bakken *et al* (1994) described the standard conditions on fur farms. Foxes are kept in wire mesh cages, with a floor area of 0.6$m^2$ to 0.8$m^2$, occasionally as much as 1.2$m^2$, and a height of 0.6 - 0.8m, occasionally as much as 1.0m. The smaller cage size is normally used for the blue fox. Cages are furnished with a nest box from the onset of the mating season until the weaning of the cubs. For the rest of the year, on most farms the foxes have nowhere to hide although a wire mesh platform is provided in some countries and sometimes wooden platforms with or without solid sides are used.

Following birth, the vixen and her cubs are generally separated at eight weeks of age, and the cubs may be kept with littermates until 10 weeks of age. Pedersen (1991, 1992) reported that while the litter remained together, they were housed in double standard fox cages, measuring 1.95 x 1.2 x 0.95m. Thereafter, foxes may be kept singly or placed in male/female pairs (generally siblings) in either single or double standard cages (Pedersen and Jeppesen 1990, Pedersen 1991). Silver foxes are said to wean an average of two to four cubs per mated vixen, while blue foxes produce twice as many (Bakken *et al* 1994).

Farmed foxes are fed daily with nutritious minced or puréed food. They are caught and handled when measuring oestrus, and during mating, fur grading, and medical treatment. On average, breeding animals are caught or moved up to 20 times per year, and cubs may be moved up to five times. Handling by humans and enclosure in a new cage are regular experiences.

Pelting occurs in November and December. Foxes, whether they are kept for pelting or breeding are housed in cages in sheds. The cages are usually in rows with mutual walls

but may be free-standing individual cages. The present farm environment developed from large ground enclosures holding many foxes, but in which hygiene was sometimes poor.

**The biology of the red fox**

The red fox is found throughout Europe, the holarctic region, in barren tundra up to 75ºN in Canada, and in the deserts of Australia, in areas with no greater than 8mm rain per year (Lloyd 1980a, Burton 1979). This enormous range is evidence of its adaptability, which in turn indicates a likely high capacity for learning. Correspondingly, the fox has been reported to have a "strong tendency to investigate the unfamiliar" (Lloyd 1980a p.12).

A male fox reaches a maximum height of 35 to 40cm tall at the shoulder (Burton 1979), with a head and body length of 56 to 77cm and a tail of length 32 to 48cm (Lloyd 1980b, see also Burton 1979). They generally weigh between six and 10kg, with a maximum of 14.3kg recorded in Norway (Burton 1979). Vixens are usually a few centimetres shorter, and weigh on average a kilogram less, although geographical variations exist, and females in one region may be larger than males in another. Local geographical variations in body size may be related to population density (Cavallini 1995).

***Habitat and home range***

In whatever habitat a red fox occupies, cover is important (Lloyd 1980a). In open country, foxes may habitually live below ground (Burton 1979). Surface cover, such as cairns of rock, boulders, and undergrowth are used as resting places, and foxes may sleep underground during bad weather (Burton 1979, Lloyd 1980a).

Many foxes become resident in a particular area and establish a home range, the sizes of which vary considerably. Studies in Northern Ireland, Denmark, Holland and Switzerland show that estimated ranges of adult foxes varied from about 400 to 1600ha each (Lloyd 1980b). In Oxfordshire (UK), where the terrain is a mixture of large gardens and farmland, home range sizes vary between 10 and 70ha (Macdonald 1987), in nearby mixed farmland, they vary between 100ha and 250ha and in the Arctic, they may be as

large as 3000ha. The dispersion of both appropriate resting shelters and available food strongly affect home range size (Lucherini *et al* 1995, Lucherini and Lovari 1996).

All areas of a home range are not used equally by foxes (Burton 1979, Lloyd 1980a); instead, researchers often detect areas of high use, and a series of pathways interconnecting these (e.g. Storm 1965, Maurel 1979). The occupation of different preferred zones within a home range tends to change over time (Ables 1969) and it has been noted, via observations in snow, that some regularly travelled paths are frequently urine-marked in the same places, whereas others are not urine-marked at all (Lloyd 1980b). The systematic activities of foxes within ranges has led some researchers to propose that foxes learn aspects of the spatial relations between places, and hence, obtain a form of cognitive map (Fabrigoule and Maurel, 1982).

***Social grouping and reproductive activity***

Some foxes are solitary whilst others live in territorial pairs (e.g. Sargeant 1972), which may stay together as long as both animals live (Lloyd 1980a). Foxes may also live in small groups (Ables 1975, Macdonald 1980, Cavallini 1996), of various structures, often one adult male and three to four adult vixens that are closely related (such as a mother and her daughters). Evidence has accumulated that generally only one vixen within a social grouping will rear offspring. In Macdonald's (1979) study, this was always the most dominant female, although the dominant individual changed occasionally between years. The subordinate, non-breeding vixens may help to rear the cubs of the dominant female: they groom, guard and bring food to the cubs. Within such groups, status-linked reproductive suppression occurs (Macdonald 1980).

The male fox may play an important role in rearing the cubs. Burton (1979) noted that there are many records of males being found with the vixen and her cubs, and described video footage of the family unit playing together. Macdonald (1979) also observed the males in his family groups to feed and play with the cubs.

***Birth and cub development***

The vixen finds a dry, protected area in which to give birth, such as an earth den. Once cubs are born, she may move them from one earth to another (Lloyd 1980b, Burton 1979). The usual litter size is four to six cubs (Lloyd 1980b, Burton 1979, Macdonald 1987). Hypothermia of young cubs can be a problem (Braastad 1996) and vixens normally spend much time close to the earth during the first 7-10 days after parturition (Macdonald 1980).

At about six weeks of age the cubs begin to emerge from their earth, but do not venture further than a few metres from the den. Nutritional weaning is complete at eight weeks. In areas of abundant cover, the den is abandoned when the cubs are about 10 weeks old (Burton 1979). Cubs usually stay with the mother until they reach adult size at six to seven months of age (Lloyd 1980a).

From approximately six months of age onwards, all male cubs and some female cubs will disperse from their natal territory (Hough 1979, Lloyd 1980a, Macdonald 1987), although some females will choose to stay (Macdonald 1980). Those that disperse may travel short distances (e.g. 2km): but distances recorded include 52km in Wales, 500km in Sweden and 394km in the USA (Lloyd 1980b, Macdonald 1987).

***Social behaviour and sensory biology***

Foxes have a sophisticated and intricate repertoire of social behaviour. A wide variety of play behaviour and sequences have been described (Burton 1979, p.40), and facial expressions accompanied by postures are used to convey information such as status (Macdonald 1987). Tembrock (1957, Burton 1979) identified 28 individual calls and recent sonographic analysis of vocalisations from 512 adults and 73 cubs suggested 20 call types, used both singly and in combination (Newton-Fisher *et al* 1993).

Foxes may be active by day, particularly where undisturbed by people (Burton 1979). Nonetheless, most activity occurs at dusk or nocturnally (Maurel 1979, Lloyd 1980b). Experiments with captive foxes suggested that foxes are likely to rely on hearing at night, their ears being sensitive to low-pitched sounds such as the rustling of a vole in

the grass (Osterholm 1964, Burton 1979). The range and complexity of fox vocalisations also testifies to the importance of the foxes' auditory environment.

As with mink (Nimon and Broom 1999), olfactory variables play an important role in the lives of wild foxes. Foxes scent-mark extensively, having several scent glands: a tail gland, two anal sacs and glands in the skin between their toes and pads. While little is known about the function of the secretion from the latter, Macdonald (1987) noted that a bloodhound (and thus, presumably another fox) could follow it for about 20 minutes after the animal had passed. Foxes sprinkle urine on empty cache sites, apparently as a reminder not to explore these again later and Macdonald (1987) states "fox urine is clearly an important feature of the vulpine lifestyle. Expression of social superiority in face-to-face encounters may be one function of scent" (p.124). Furthermore, he added that the insulating properties of grass, woodlands and open plough, together with the effects of wind and shade, must make each foxes' territory an ever shifting patchwork of olfactory information. He suggested, for example, that trespassing foxes may chart a route through poorly scented terrain. This is an aspect of their environment which we cannot sense.

***The biology of the Arctic fox***

Burton (1979) remarked that, apart from the polar bear, no other carnivore is virtually confined to the tundra, nor so well adapted to life in cold climates. Arctic foxes are smaller than red foxes: in males, the height at the shoulder is 30cm, the body length is 50 to 65cm, the tail extends 28 to 33cm, and weight ranges from 4.5 to 8kg.

On the tundra, they do not hibernate, but remain active and have been seen hunting in temperatures of -45C (Burton 1979). Unlike the red fox, the Arctic fox is nomadic. It can travel many kilometres off shore over pack ice. Perry (1973) recorded a marked fox travelling 9000km from its birthplace. The Arctic fox has been described as less wary of humans than the red fox, and often enters the camps of visitors to the Arctic to be hand-fed (Burton 1979).

In most other aspects of biology and behaviour, the Arctic fox is very similar to the red fox. Macdonald (1987) considered that red foxes probably treat Arctic foxes as inferior conspecifics and Frafjord et al (1989) describe their interactions. Where fur harvesters have introduced them to the same island, it is clear that the red fox out-competes the Arctic fox (Macdonald 1987).

**Summary of biology and relationship to fur farms**

Extensive studies of these foxes throughout their distribution have revealed that they are complex animals. They spend a long time rearing their cubs. Many individuals which have been monitored travel long distances and red foxes make patterned use of large home ranges. Social behaviour is wide and varied, and social status is evidently important, strongly affecting group relations and productivity. Males, as well as non-breeding vixens, play a role in rearing the cubs. Reproduction is evidently controlled by complex factors, including social interaction, and can vary considerably across years and locations. Foxes seek cover regularly, and make use of several dens. Those wary of conspecifics may attempt to avoid leaving scent trails, and the relative importance of scent-marking of paths and caches via urine or gland secretions has not been fully assessed. Foxes are probably capable of a high degree of learning, including the possible use of cognitive maps.

The red fox has been described as the most successful European carnivore because it has survived persecution and even flourished during the spread of urban development (Burton 1979). However, while urban development does not necessarily deprive foxes of their needs, it is clear that the barren, socially artificial conditions on fur farms are likely to do so.

**Excessive fear of humans: modification by selective breeding**

Farmed foxes are reported to exhibit "extreme fear", involving trembling defecating, withdrawing to the back of the cage, and attempting to bite handlers (Tennessen 1988 p.392). Bakken *et al* 1994 referred to a state of "continuous fear". These responses

were found by Moe and Bakken (1998) to be comparable to human fear responses and were associated with stress-induced hyperthermia.

A large-scale domestication experiment in Siberia selectively bred silver foxes for the elimination of negative, defensive responses to humans (Belyaev and Trut 1963, Belyaev 1979). This produced a population of foxes which behaved rather like domestic dogs, see photographs in Trut (1995). In a two-year study, comparing 150 cubs from the selected population with 123 cubs from unselected foxes bred for commercial purposes, Belyaev *et al* (1985) found that domestication extended the period during which cubs could habituate to people. Cubs from the selected population showed enhanced sensory development (e.g. accelerated eye opening) and the sensitive period for socialisation was prolonged to 65 days of age. They showed no fearful behaviour towards the novel stimulus of being placed in a new cage, and they exhibited less fear than controls in response to humans. The control cubs had a shorter socialisation period (lasting up to 45 days), following which they exhibited fear in response to novel stimuli. These studies suggest that selective breeding for domestication in silver foxes can significantly reduce fear responses not only to humans, but also to novel stimuli. It has also been reported that females from the selected fox population came on heat earlier, and that fertile mating sometimes occurred twice a year (Naumenko and Belyaev 1980, Trut 1981). Further experiments using fox populations selected for domesticated behaviour have suggested that changes in brain chemistry accompany the divergence between tame and wild foxes (Popova *et al* 1991, Dygalo and Kalinina 1994), and that domestication affects the development of the pituitary system, which is involved in the expression of fear and aggression in mammals (Malyshenko 1982, Trut and Oskina 1985, Plyusnina *et al* 1991).

Other tests of foxes selectively bred for lack of fear towards humans have recently produced similar results. Harri *et al* (1997) purchased from Russia, silver foxes (strain A) that had been selectively bred in this way for 37 generations. After weaning, they were housed, one animal per standard wire mesh cage, either (A1) with strain A neighbours or (A2) with normal farm strain B neighbours. In adulthood, their behaviour was compared with that of nine strain B foxes. A higher proportion of both A1 and A2 foxes ate despite

a human standing in front of their cage than did B foxes ($p<0.001$). A higher proportion of these A foxes accepted a hand-fed treat than did B foxes ($P<0.001$). In what is referred to as a "pair contest situation" against B foxes, A foxes monopolised food in 9 out of 10 cases. The A foxes had lower concentrations of plasma cortisol before and 20 minutes after handling than did the B foxes. Differences between the A1 and A2 groups were not significant. Thus, it seems that selection for reduced fear over many generations caused foxes to show significantly reduced behavioural and physiological responses to people and handling, and may have improved confidence with regard to other foxes, despite the neighbours amongst which they were housed.

These results highlight the importance of work that examines the physiological and behavioural responses of selectively bred foxes to standard stimuli in the farm environment, at different ages and under the various conditions which occur frequently (e.g. regular re-housing). Bakken *et al* (1994) cited several shorter lasting selection experiments in Nordic countries which they reported also show that it is possible to select against fear and in favour of curiosity. Further selection programmes are in progress and papers reporting these are expected.

**Excessive fear of humans: modification by early handling and regular contact**

Attempts to reduce fear of humans and the farm environment in general have also examined the possibility of early handling and human contact as an effective treatment. Pedersen and Jeppesen (1990) reviewed a number of studies which showed that handling early in the life of captive or domestic animals is often associated with less fear, more exploratory behaviour, and a better ability to cope in novel situations. Their review suggested that the best results occur when animals are handled during their sensitive periods for socialisation, although positive results had been achieved when handling occurred before or afterwards. Separation from the mother occurs much earlier on farms than in the wild and this is likely to be a period of sensitivity to human socialisation.

Tennessen (1988) examined the effects of regular human contact on silver fox cubs. Three treatments were involved: five minutes of play with a handler each weekday

(group 1), being picked up briefly each weekday (group 2), or no extra handling (group 3). Tests of fear and exploratory behaviour at 15 weeks and at 6 months showed that those in group 1 showed less fearful and more exploratory behaviour in a novel situation, and the ranking of fearful behavioural responses to the presence of a human outside the cage was ordered with group 3>group 2>group 1. Pedersen and Jeppesen (1990) exposed 32 silver fox cubs to a handling treatment in which they were fondled and talked to in the cage for five minutes, twice a day, six days a week, from two to eight weeks of age (i.e. including the socialisation period). Control cubs (n=46) were not exposed to handling during this time. The cubs were not differentially treated between eight and 12 weeks, but were all subjected to normal farm procedures. At the age of 12, 15, 18 and 20 weeks, all cubs were tested with three different behavioural tests, including close eye contact with a human, a hand punched rapidly towards the cage without hitting it, and a glove on a stick pushed into the cage. At the age of 24 weeks, all foxes were blood sampled and exposed to an open field test: a measure of fear and exploration in a new, larger cage arena. The results demonstrated that the group handled during early development showed a significantly reduced fear response in tests made at later ages. The effect seemed to be related to all humans, not only those who performed the handling. The behavioural and physiological results from the open field test were interpreted as suggesting that the control group experienced chronic stress, whereas the handled group were thought to be generally less stressed by their farm environment.

In a large-scale study, Pedersen (1992) studied the effects of early handling at different ages in 344 silver fox cubs. Seven groups were handled at different ages before, during and post-weaning, for either three, six or 12 week. Handling occurred twice a day for five minutes, five days a week, and involved fondling and talking to the cub. Cubs were subjected to behavioural tests of response to a human outside the cage, and a human opening the cage door and reaching out to the fox, at 18, 24, 30 and 32 weeks.

Results indicated that, in comparison with a control group, foxes handled during or after weaning for three weeks or more later showed reduced fear responses towards humans at all ages tested except for 30 weeks. Again, the changing of experimenters

suggested that this effect was generalised to all humans and not just those which had done the handling. Pedersen (1992) suggested that the failure to find a significantly lower fear response in handled cubs at 30 weeks of age was the effect of a single blood sampling session at 26 weeks (thus, causing a temporary association between appearance of a human and pain). Results also suggested that handling before weaning (at eight weeks of age) had to be performed for six weeks or more to produce a reduction in fearfulness. These results do not compare exactly to the suggestions arising from Belyaev *et al* 's (1985) discussion of socialisation periods: here, handling was most effective when targeted at cubs of approximately 56 days of age, rather than the 35 to 45 day "optimal" period suggested by the earlier work.

Pedersen (1993a) furthered the results of her earlier experiments with a study of silver fox cubs assigned to control, forced handling or gentle handling, twice daily for three weeks post-weaning. Forced handling involved capturing the cub with one hand on its tail and one under its stomach, transporting it to a smaller cage for two minutes, then capturing it in the same manner and returning it to the home cage. During gentle handling, the human slowly opened the cage door, fondled the cub and offered scraps of food, making no fast movements and withdrawing if the cub showed signs of fear. Behavioural tests were again used to compare groups at 18, 24, 30 and 32 weeks of age, on this occasion involving responses to the same two tests as reported in Pedersen (1992), as well as a the glove test reported in Pedersen and Jeppesen (1990).

While both handled groups showed less fear and more exploratory behaviour than the control group, it was not possible to conclude that one handling technique was more beneficial than the other in habituating foxes to the farm environment and its associated disturbances. Gently-handled foxes showed a lesser reaction to humans both known and unknown to them, but forcibly handled foxes showed more exploratory behaviour when exposed to novel stimuli.

Pedersen (1994) then questioned whether these early handling treatments might have beneficial effects in the longer term also. She noted that many studies have found

early handling of farm animals to have immediate or short-term benefits on behaviour or physiology (e.g. Hemsworth *et al* 1981, Hargreaves and Hutson 1990, Podberscek *et al* 1991), but sometimes also suggested that later benefits accrued (Heird *et al* 1986). Firstly, she reported that the female foxes used in Pedersen (1993a) were compared during their first breeding season, and it was found that forcibly handled vixens showed better reproductive performance than both gently handled and non-handled vixens (Pedersen 1993b). Then she tested the same subjects used in Pedersen (1993a) with the same tests at 10, 13, 15 and 18 months of age.

The results indeed showed that handling of foxes for three weeks post-weaning had long-lasting effects on both behavioural and physiological parameters, but little effect on production-related parameters. Both handled groups showed significantly reduced fear reactions to the tests in comparison with controls, however the effects of "forced" handling were more pervasive. Gently handled animals showed reduced fear when a human stood outside the cage, and when the novel object was put in the cage, but only forcibly handled animals continued to show reduced fear in response to the cage door opening, and the human reaching for the animal. Pedersen (1994) offers the explanation that the positive association developed during gentle handling, which was specifically associated with feeding, may have been overshadowed by experience of normal farm procedures, such as capture, heat determination, etc. Both handled groups had significantly lower adrenal weights at 22 months of age, suggesting generally lower stress levels. Parameters such as body weight, body size, gastric ulceration (the extent of which was low) and pelt quality were not significantly different between the three groups, thus early handling cannot be considered an economic risk. A further conclusion from this study was that non-handled foxes were chronically stressed, as indicated by their high adrenal weights and high levels of fear.

Clear effects of handling on reproduction and fear of humans were apparent in a study of 87 primiparous blue fox vixens by Dalsgaard and Pedersen (1999). Half of the vixens had been handled gently as cubs from 7 to 10 weeks of age for 2 minutes per day,

5 days per week while half were non-handled controls. Handled vixens came into heat earlier, weaned more cubs and showed less fear responses to some test situations.

In an alternative approach, Pedersen (1991) exposed cubs to constant visual contact with the farm environment (rather than actual handling) from two to eight weeks of age. For cubs in the experimental group (both silver fox cubs (n=71) and blue fox cubs (n=141)), the solid wooden walls of the usual nest box were removed to reveal mesh walls when cubs were two weeks of age. The control group (33 silver fox cubs and 77 blue fox cubs) were left with standard wooden nest boxes. Cubs were again weaned at eight weeks by removal of the vixen, and then at 10 weeks placed in new cages in pairs. Tests of behavioural response to a human outside the cage were conducted on silver foxes between 14 and 28 weeks of age: blue foxes were tested between 12 and 26 weeks of age. Experimental cubs showed significantly reduced fear responses to humans, suggesting that visual exposure led to habituation to events outside the cage. However, this experiment did not examine responses to other novel stimuli, thus failing to indicate whether habituation was specific to humans, or was generalised to any other events that might occur during management procedures. Visual exposure and handling may help cubs to become less fearful but the relative effects of visual exposure and of handling are not known. Absence of an opaque shelter within which the fox can hide forces the animal to have more visual contact with humans. A study of blue fox cubs by Bertelsen (1996, reviewed by Pedersen 1998) showed that those with no such shelter from 10 weeks of age were more fearful than those with a shelter in one test but not significantly different in another. Since the foxes are frightened by humans and often use the shelter when humans approach, their welfare is improved by the presence of the shelter on most occasions. Reduced adaptation to human presence, as a result of the possibility to hide, will result in poorer welfare when exposure to humans without a shelter is forced. However, forced exposure is much less common than the frequent exposure to humans during feeding and other farm work when a shelter could be used. The net effect of a well-designed nest box or other shelter is better welfare.

Altogether, these studies make a strong case that early handling of cubs has beneficial effects on their welfare. The work of Pedersen (1994) indicates that early handling can have long lasting positive effects on captive fox welfare. In this case, the treatment tested was handling for three weeks post-weaning, however, work reported in Pedersen (1992) suggested that handling during weaning may have similar effects. Furthermore, "forced" handling had stronger effects than "gentle" handling, although it is important to emphasise that “forced” refers to a specific mode of handling and should not be taken to mean “rough” handling. Forced handling also involved transportation to a new cage, hence early experience of a new environment. Tennessen's (1988) experiment found more positive effects from five minutes of contact, and movement to a new cage, than being picked up briefly. Gentle handling did not involve picking up or moving the cub, and may have had a different result if food had not been offered. For example, Bakken (1994 a, b) reported results which suggest that the act of offering food items in itself may have effects on foxes. He visited one group of pregnant vixens twice a week and offered them food scraps by hand; another group received the same amount of human contact, but no food. Significant differences existed between the female cubs born to the two groups, with the females in group 1 being more active and less fearful at 30 days of age than those from group 2. Bakken suggested that the act of offering food items was more effective than human contact alone in reducing the fear of humans in vixens, and that this affected the behavioural development of cubs. In another experiment (Bakken *et al* 1993), silver fox vixens that had learned to associate delivery of food scraps with a particular person showed sudden, strong behavioural and physiological responses when that person captured and handled them. Hence, as suggested by Pedersen (1994), gently handled foxes may have reacted more strongly to later handling not involving food, than those which had never learned to make an association between handling and feeding.

In all, it seems that it is still not possible to precisely define the single most beneficial handling and human contact regime for fox cubs. For example, what are the acceptable age limits within which handling has a broadly equivalent effect? Such information could help to encourage appropriate practices amongst fox breeders. Nonetheless, there is sufficient evidence that early handling and contact with the farm

environment will benefit both foxes and farmers. Breeders should be encouraged to provide daily handling in the three week period following weaning, if possible, involving brief transportation to another cage.

Bakken *et al* (1994) also noted that contact between foxes and caretakers seems to be important. They concluded that daily inspection, coupled with offering a biscuit, quickly reduced fear of humans, and improved reproduction in multiparous vixens. It may well be true that habituation to the presence of human outside the cage is enhanced by maintaining daily contact, and that further benefits accrue. On the other hand, recent research, reported in Braastad *et al* (1997) emphasised that not every kind of human contact is of benefit to animals: when pregnant blue fox vixens were handled for one minute daily in the last third of their gestation, their offspring showed signs of significant negative effects. Careful research on human/farm fox interaction must ensure that handling and treatment procedures can be described in sufficient detail so as to rule out the possibility of misinterpretation during practice.

**Physical aspects of the cage: size, materials and placement**

Fox farms have come under public criticism for the small size of cages and the use of wire mesh for floors, which would appear to be uncomfortable to walk upon. Small variations in cage size with no enrichment do not have much effect on fox behaviour or physiology (Pedersen and Jeppesen 1998). Korhonen et al (1999) reported initial results from experiments designed to examine how farm foxes would choose between cage sizes and floor types. Blue foxes (16 adult, eight juvenile), initially housed in a standard mesh cage (0.8m x 1.05m floor area), were transferred to cages of 1.2m by 1.05m, then cages of 2.4m by 1.05m, then finally given access to an earthen floor enclosure (1.2m x 1.05m) immediately below the cage. Each of these conditions prevailed for two weeks. Foxes showed no change in activity as cage size increased and few foxes showed a tendency towards digging. Similarly, blue foxes housed in groups of two to six in large earthen-floor enclosures did not make even use of the available space, but tended to prefer certain areas for unidentified reasons (Korhonen *et al* 1991) and results reported by Alasuutari and Korhonen (1992) in relation to eight foxes housed in one large enclosure (surface

area of 224m$^2$) show the same tendency. Bakken *et al* (1994) reported as yet unpublished work by Korhonen in which farm foxes showed no clear preference when given the choice between conventional cages or eight-square-metre enclosures on the ground, and another experiment in which the only change in behaviour seen when single foxes were housed in cages varying between one and eight square metres of floor size was that those in larger cages displayed more active escape behaviour, gradually reduced in silver foxes but not in blue foxes.

The evidence regarding increased cage size is difficult to assess. Wild foxes do not use all areas of their home range equally, and may benefit from large enclosures such as that in Alasuutari and Korhonen (1992) to a greater extent than has yet been measured. Nonetheless, behavioural evidence does not suggest that an increase in cage size in the order of 700% is a valuable resource to farm foxes. Yet, resources and opportunities for complex behaviour are likely to be more important than space alone. Furthermore, research to date has examined cage size use and preference in adult farm foxes with no early experience of different cage sizes: cubs exposed to larger areas for play and exercise could be expected to make use of these facilities as adults. Merely increasing cage size, without simultaneously increasing the complexity of the environment, may be of no positive benefit to farm foxes reared without such facilities, but as yet research does not indicate that cages could not be improved in ways that might include additional space.

With regard to floor type, as examined by Korhonen et al (1999), results are inconclusive. Given large variations in earthen floor usage amongst a small sample, and the potential effects of a fixed order of treatment on behaviour, further large-scale investigation might provide different results. Jeppesen and Pedersen (1990) and Skovgaard et al (1998) found that foxes raised on wire floors showed no preference for solid floors. A raised wire floor was preferred to an earthern floor (Korhonen et al 1999). However, it could be that early experience on wire is very influential and it is also possible that two floor types are preferable to one. Bakken *et al* (1994) suggest that the cage system should be equipped with a portion of solid bottom or finely meshed wire

554 when cubs are small, for young cubs with poor co-ordination avoid walking on large
555 meshed wire floors.
556
557 Harri *et al* (1995b) noted that one experiment (Korhonen and Niemelä 1997) had
558 unexpectedly shown that both silver and blue foxes spent more time in a high-mounted
559 wire mesh cage than in an earthen floor enclosure which was four times as large. These
560 results, they reasoned, reflected the fact that silver foxes like to be in a high position with
561 respect to their surroundings. They tested silver foxes' preference for floor level against
562 preference for floor type with the use of two standard cages, joined through contiguous
563 holes, one of which had a wire floor, the other had a floor covered in a sand and peat
564 mixture. Both cages had food and water and the experiment was divided into two week
565 periods, during which: a) both floors were at ground level; b) the wire floor was raised
566 50cm higher, c) the sand and peat floor was raised 50cm higher (and the wire floor
567 returned to ground level), d) both floors were raised to the height of 50cm.
568
569 In this study, foxes showed a preference for the sand and peat floor for both rest and
570 activity. This was most noticeable at the beginning of the experiment, when both floors
571 were at the same (ground) level. Use of the wire mesh floor cage as a resting area
572 increased when it was raised 50cm higher, and its use during resting remained at about
573 the same level when it was subsequently lowered and raised. This suggests that the wire
574 floor had some value as a resting place, possibly because of the exceptionally hot weather
575 which the authors reported accompanied the experiment. However, regardless of the
576 position of the wire floor cage, the other cage was used more for activity and as much or
577 more for resting. The authors also commented that the study by Korhonen and Niemelä
578 (1997) which found equal distribution of activity between a wire bottom and a solid
579 bottom cage (and, thus, is possibly one of those studies referred to by Bakken *et al* 1994)
580 used a long tunnel rather than a single hole to connect the cages: thus, it is possible, that
581 the apparently equal distribution of activity reflected a preference to travel through the
582 tunnel, rather than a preference for floor type. Whether or not this is what occurred, such
583 a suggestion highlights the importance of identifying extraneous variables which may
584 erroneously create or hide an effect.

Results obtained by Harri *et al* (1995b) therefore suggest that adult silver foxes show a preference for a solid floor, at least when that floor is higher, at the same level, or no less than 50cm below, a wire floor. The wire floor section of the modified cage, however, was used in 97% of defecations, suggesting that foxes in cages equipped with a portion of each type of flooring may quickly learn to defecate over the wire, thus ensuring cage hygiene.

Two inconclusive studies have attempted to examine the implications of the physical placement of cages on a fox farm. Kaleta and Stosznajder (1990) reported that, in response to a human approaching rapidly, foxes housed in cages placed in the standard "pavilion" sheds showed withdrawal and immobilisation, whereas foxes in free-standing cages showed a greater tendency to try to escape. The result was that foxes in pavilion cages allowed human observers to approach more closely, but this result did not demonstrate that foxes showed less fear under either condition. The authors concluded that the presence of farm workers was more disturbing for animals in pavilions, although it is not possible to judge whether this conclusion is justified. In another paper, Kaleta and Plochocka (1990) studied 534 two month old silver foxes of both sexes, housed in pairs in free-standing cages. They looked at the relationship between aisle width and the distance at which the foxes first moved away from an approaching human ("escape distance"). Foxes were approached perpendicularly, presumably as an attempt to control for the effects of the differing widths of aisles. Results showed a positive correlation between aisle width and escape distance, for example, when the aisle width was 1.4m, escape distance was 1.03m, when aisle width was 3.9m, escape distance was 2.0m. This result seems to have little relevance: when the aisle is a few metres wider, the fox reacts to an observer who is further away. This is unsurprising because a person three metres away in an aisle 1.4m wide may not be as visible to a fox as a person three metres away in an aisle 4m wide. This experiment justifies no real conclusion with regard to the differential welfare implications of the width of aisles.

**Enrichment of the barren cage environment**

Efforts to provide environmental enrichment for farmed foxes have focused on the provision of nest boxes outside of the breeding period, and on observation or resting platforms. Extensive studies have examined use and preferences of both species under a variety of conditions.

There is good evidence that additional shelters, whether platforms or nest boxes, are not necessary for adult foxes to protect themselves from cold weather. Experiments on animal models found that fur provides a six-fold reduction in heat loss: with fur, heat loss is only 10% less inside a nest box than lying outside on wire mesh (Harri *et al* 1989). Further experiments found that the saving in heat loss when a fox model was stretched out across a wooden platform was so low as to be of no practical use to the animal (Bakken *et al* 1994) and Scholander *et al* (1950) estimated that an Arctic fox does not have to increase its basal metabolic rate until the temperature falls below -40C. Observations have shown that the use of platforms and nest boxes in both species decreases with decreasing temperature, and that use drops in winter (Harri *et al* 1988, 1991, 1992, Korhonen *et al* 1991, Mononen *et al* 1993; Korhonen and Niemelä 1996c, Korhonen *et al* 1996).

***Nest box for foxes***

Some studies indicate that year-round provision of a nest box can significantly improve welfare. In a two year study of 100 silver fox vixens, Jeppesen and Pedersen (1991) found that animals in cages provided with such nest boxes spent between five and 25% of their time inside it under quiet conditions. When disturbed, those with nest boxes either hid in them or moved closer to them, whereas control foxes moved to the back of the cage. At the end of the study, foxes which had been housed with nest boxes had lower base levels of cortisol and eosinophils, and higher base levels of lymphocytes, suggesting lower stress levels than that of control animals. They gave less fearful responses to humans outside the cage, and showed more activity and exploration in an open field test. The possibility that escape to a nest box may have provided foxes with some degree of control over their interactions with the outside world is supported by the authors' observations that the control animals acted as if they were in a uncontrollable stressful situation.

The extent to which foxes use year-round nest boxes has been the subject of considerable debate as figures for mean usage vary between individuals and between studies. Harri *et al* (1992) provided pairs of weaned silver foxes with nest boxes on the floor of the cage. They found that foxes spent very little time in them, but spent a major part of their daily time on the roof of the nest box. Mononen *et al* (1995b), in a study of 36 pairs and eight singly-housed juvenile silver foxes provided with floor-level nest boxes, also found them to spend only one to two per cent of their time inside nest boxes, but more than 50% (over a 24 hour period) on the roofs of nest boxes. These authors supposed that this behaviour might result from the fact that placement of the nest box took up part of the floor space and restricted the view of the surroundings. Mononen *et al* (1996a) made a further assessment of the preferences of both silver and blue foxes for cages containing floor-level nest boxes, using a set-up in which one cage, provided with a nest box, was joined via an opening to a standard, empty cage. They found that both species spent more time in the cage containing the nest box, although not necessarily in the nest box itself, and only silver foxes showed a strong preference for the roof of the nest box as a resting site (44% of daily time was spent there). In the wild, foxes may rest within the vicinity of a den, without actually entering (Weber 1985) thus, as has also been concluded by Bakken *et al* (1994), it is not necessarily the case that dens (or nest boxes) are not important to foxes that do not make high use of them.

The height at which a nest box is placed may have additional welfare implications. Pedersen and Jeppesen (1990) found that silver foxes spent 80% of their time at night inside nest boxes which were mounted on the roof of the cage and accessible via a platform. Similarly, (Jeppesen and Pedersen 1990) vixens preferred a nest box under the roof to a box on the floor. In a study conducted during farm working hours only, Pedersen and Jeppesen (1993) observed silver and blue foxes in complex cages involving access to an open-topped, floor-level box, an adjoining, closed nest box, and a nest box mounted on top of the cage, with a platform beneath. Both fox species used the nest boxes to varying degrees over the study period: for example use increased just before the breeding season, as is true of den use amongst wild foxes (Macdonald 1980). Silver foxes used all types of constructions frequently at the beginning of each observation period,

678 suggesting that a high level of activity throughout the nest box system was provoked by
679 the renewed presence of the observer walking past the cages. When actively disturbed by
680 a person hitting the cage with a stick, silver foxes fled to the opposite side of the cage, or
681 into the top box; most of the blue foxes fled into the top box. Both species of foxes
682 preferred the top box and the shelf beneath: silver foxes spent most time on the shelf, blue
683 foxes spent most time in the top box. This study clearly shows that nest boxes were more
684 attractive to both species when they were mounted above the cage.
685
686 The experimental set-up used in this study involved two standard cages with an
687 access hole between them, a ladder against either side of the adjoining hole, and the nest
688 box additions to one side of the cage: thus, in effect, housing conditions were both
689 enriched and enlarged. Foxes used in experiments might have been shown to benefit from
690 this if they had been compared with controls in standard cages. Nonetheless, no direct
691 measurement was made of the effects of increased size in conjunction with a more
692 complex environment.
693
694 Another aspect of this study is that all individuals used all of the space available
695 during active behaviours. While experiments reported above (e.g. Korhonen *et al* 1991)
696 found that foxes used only small areas of large barren enclosures, this cage system was
697 both enlarged and more complicated, involving climbing ladders and jumping onto the
698 nest box. Harri *et al* (1995a) reported that when standard size cages were joined by a
699 simple opening, silver foxes changed sides up to 250 times a day, but when cages were
700 connected with a long (1.5m) tunnel, the number of cage exchanges ranged as high as 500
701 times per hour. These observations suggest that foxes have responded with increased
702 activity to increases in the complexity of the standard barren cage.
703
704 With regard to the nest box itself, a few studies have examined design issues.
705 Although farmed adult foxes do not need additional thermal protection from the
706 environment, fox cubs in their first few weeks of life are vulnerable to hypothermia.
707 However, extra insulation of the nest box makes little difference in cubs' rate of heat loss
708 (Bakken *et al* 1994); neither does the extent of ventilation provided in commercially

available nest boxes make a significant difference to the thermal environment, even under windy conditions (Harri *et al* 1989). As the most important source of heat to cubs is the presence of the vixen, Bakken *et al* (1994) recommended that cubs will have the best chance of survival with selection of foxes for good maternal care.

However, Braastad (1990a) reported that when the nest box was equipped with a narrow entrance tunnel, a smaller proportion of vixens committed infanticide, and average litter size at weaning was 0.5 cubs higher than in foxes with standard breeding boxes. In a study of 834 silver fox vixens on nine farms, Braastad (1994) found that vixens provided with a nest box that included an entrance tunnel (20cm (L) x 18cm (W): see Braastad 1994 Fig. 1.) bore more offspring and had lower cub mortality up to three weeks after birth. The effect was more pronounced in primiparous vixens, which are often less successful, and was not seen at all at two farms that had high reproductive success, thus suggesting that such a design can improve sub-optimal breeding success. Behavioural observations indicated that vixens were calmer, and did not show increased activity during working hours as is typical for vixens in traditional boxes (Braastad 1992, 1994). It would seem that this improvement to the traditional next box benefits silver foxes both in terms of their welfare and reproductive success.

***Observation platforms and an unobstructed view***

Early work in which foxes were provided with platforms 20 to 30cm from the cage roof suggested that they were used to view the surroundings, much as has been reported for Arctic foxes in the wild (Chesemore 1986, Korhonen *et al* 1991). Seventeen of 18 blue foxes provided with wooden or wire shelves preferred to sleep on the wire cage floor, however all animals used the shelves, to different extents (Harri *et al* 1988). Shelves were generally used for short bursts of activity only, and generally during farm working hours, particularly as animals awaited feeding. Harri *et al* (1991) found that all 47 experimental blue foxes used platforms: on average, for 6.8% of their daily time, although some individuals lay on a platform for hours. Korhonen *et al* (1991), studying blue foxes in varying size enclosures, also found that foxes preferred to sleep on the cage floor, but those provided with shelves used them as a vantage point. Harri *et al* (1992) found that

740 silver foxes preferred platforms from which they could observe the shed house door to
741 platforms facing in the opposite direction ($p<0.001$). They also reported that any
742 "extraneous" disturbances on the farm led foxes to use platforms. Korhonen and Niemelä
743 (1996c) reported that silver fox use of platforms was high, with the greatest use made
744 between four and 5a.m.
745
746 The evidence indicates that foxes make greater use of platforms that do not have
747 walls. Harri *et al* (1991) found a highly significant difference in blue fox usage of
748 platforms with and without walls. Korhonen and Niemelä (1996a) compared the use of
749 walled and open platforms in two groups of 30 foxes each. They found that in both sexes,
750 foxes made significantly greater use of open platforms. They were used for jumping,
751 resting and sleeping upon. A disturbance test, in which an experimenter struck the cage
752 with a stick, indicated that most foxes jumped onto open platforms (62.5% of males and
753 85.7% of females), but significantly less use was made of walled platforms. The authors
754 concluded that foxes avoided walled platforms because they prevented observation of the
755 surroundings. The likelihood that the opportunity to observe surroundings is important to
756 foxes has been further supported by Mononen *et al* (1995a, 1996b). They housed a small
757 number of adult silver and blue foxes (four of each) in double cages and used wooden
758 boards to alternately obstruct the view that was available from a lying position in each
759 cage. Both species spent a lesser proportion of their time in the cage with an obstructed
760 view, and almost exclusively preferred the cage with an unobstructed view as a resting
761 place. They concluded that an unobstructed view is a key feature of housing design.
762
763 This poses the question of what exactly foxes are viewing. Evidence from Rekilä *et*
764 *al* (1994, 1996) suggested that adult farmed foxes are affected by the environment outside
765 of the cage. They found that foxes from cages in the front half of the rows in sheds
766 appeared better adjusted to the farm environment than those in cages at the rear. These
767 foxes were more active, both in the home cage and in an open field test, and the majority
768 were sufficiently confident to eat in the presence of a human outside the cage (this was
769 not true of foxes from rear cages). It seems likely, as the authors suggested, that this
770 difference arose because foxes near the front of the barn were more frequently exposed to

humans and regular farm activities, and thus became habituated, or were better adjusted because of higher levels of sensory stimulation. An unexplained finding in a study of platform use by Korhonen and Niemelä (1994b) - that the location within the cage of platforms affected usage - might be explained by factors present in the external environment, such as how many other foxes have platforms, the social relationships between neighbours, and the extent and nature of activities that occur in the vicinity. Factors in the external environment may also explain the often remarked high degree of inter-individual and inter-study variation in platform use (see Bakken *et al* 1994).

The extent of platform use varies seasonally. Korhonen and Niemelä (1994b) suggested that platform use by blue foxes during winter was so low as to render them unnecessary at this time: only five to 15% of animals used platforms at all during mid-winter. However, Korhonen *et al* (1996) and Korhonen and Niemelä (1996c) agreed that platforms could be recommended for both fox species, particularly during spring and summer. Studying male and female blue foxes throughout the year, Korhonen *et al* (1996) found that platform use by all experimental animals was highest from August to October. Lactating vixens tended to lie on the nest box roof rather than the platform, but male and non-breeding vixens showed high platform usage during the whelping season, with platforms predominantly used for sleep. In a study of 120 silver foxes and 300 blue foxes, Korhonen and Niemelä (1994c) also reported that platforms were used predominantly for sleeping, thus it is clear that the utility of platforms is not restricted to use as a vantage point during short visits.

In terms of production parameters, no differences between weight gain or reproductive performance were found in a comparison of blue foxes housed with and without platforms (Korhonen and Niemelä 1994a). Wire mesh platforms remained cleaner, and fur quality and clarity were significantly negatively correlated with cleanliness of platform. As blue foxes used wire and wooden platforms equally, the authors concluded that a wire mesh platform was probably preferable from the farmers' point of view.

In terms of general fearfulness, Korhonen and Niemelä (1996d) administered several behavioural tests to silver foxes housed in groups with and without platforms. Altogether, there was no difference in general fearfulness between the two groups, although those housed with platforms were significantly less fearful of humans. While Rekilä *et al* (1996) reported that blue foxes housed either with year-round nest boxes or platforms were no less fearful of humans than control foxes, one can at least conclude that these modifications to the environment did not cause blue foxes to be more fearful of humans because of reduced contact.

Although reproductive success may not be improved, and fearfulness of humans is not always reduced, and despite seasonal, individual and species variations in platform use, it is clear that the addition of platforms to cages provides environmental enrichment. These studies have shown that they have been used by foxes of both species for a range of biologically appropriate behaviours, and they evidently can increase the complexity of the environment for foxes. Furthermore, it seems that the available view of the surroundings, and the events that occur outside of the cage environment should be considered as aspects of housing design. In some countries, platforms must be provided in fox cages. The evidence suggests that simultaneously increasing the cage size and complexity will have a positive effect on farmed foxes.

**The social environment: group housing and effects on reproduction and welfare**

The possibility of housing farmed foxes in enriched or semi-natural enclosures in social groups has also been examined. Korhonen and Niemelä (1996b) devised a complex, enriched environment involving several tunnels, two earthen-floor-enclosures, top-mounted and floor-level nest boxes, and a variety of platforms. Here, they housed 16 male and 14 female juvenile blue foxes. These animals were handled by three different handlers for a period of 10 minutes, five days a week, for an unknown period. A few months later, they were compared, in terms of behaviour and production parameters, to cubs housed singly in standard barren cages from the same litter. These foxes had not been handled.

Some positive aspects arose from the complex housing, indicating an enriching effect on foxes. The housing provided appropriate opportunities for foxes to rest, observe their surroundings, retreat from each other, interact, bite and dig. The authors conducted an evaluation of fear in relation to humans by putting each experimental fox into a single cage, then opening the door and scoring the reaction to a person reaching inside. They concluded, on the basis of their results, that handling had a positive effect on foxes' reactions to humans, although this is not truly evident from the results given that the only reported difference is that four more animals from the handled group were assessed as being curious rather than fearful. Handling was not conducted in the manner that has been proven to have long lasting effects on fox cubs (see above), it occurred later than the optimal period, and may not have involved all cubs, for the handler only touched those that approached him or her. It is not clear whether the same conditions prevailed for experimental and control animals during the fear test, i.e. whether control animals were placed into new cages prior to testing or whether they were housed in their home cage. If the latter is true, the lack of difference between experimental and control animals might be taken to indicate greater confidence in new environments amongst experimental animals. This therefore might be the effect of physical or social enrichment, as well as handling.

However, negative effects of social interaction arose. Although more feed had to be given to experimental animals (amounting to 50g per fox per day) to ensure that all were able to feed, experimental females were significantly lighter than control foxes (there was no difference between the groups of males). Strongly manifested dominance relations prevented lower-ranking animals, often females, from feeding as much as higher-ranking foxes, as was also reported in the group housing experiments of Korhonen and Alasuutari (1994, 1995). Fur quality was poor amongst all group-housed foxes, at least partly because of biting, but no control group foxes had poor quality fur. Reproductive behaviour showed some parallels with behaviour in the wild: following whelping, females moved cubs between different nest boxes almost daily, and occasionally a non-breeding female assisted with cubs. However, only two females had litters, and only three cubs from one of those litters survived. The average number of surviving cubs amongst control

females was 7.9. As Korhonen and Niemelä (1996b) conclude, these effects on body size, fur quality and reproduction would not seem to render group housing of this type a practical option for farmers.

On the whole, group housing experiments have shown poor reproductive success (Kullberg and Angerbjörn 1992, Korhonen and Alasuutari 1991, 1992, 1994, 1995) Yet, the authors recognise that their attempts at social enrichment have not been optimal: social groups which occur in the wild involve closely related animals only, and this has not been true of most of these experiments. In the one situation in which one male blue fox was housed with only three female sisters, two successfully raised litters and the female who lost her litter helped in raising another's cubs. In this same group, the father stayed close to one of the successful mothers, stayed with the cubs and brought food to the mother.

Bakken *et al* (1994) described unidentified Danish studies of both silver and blue foxes in which animals were kept in group sizes of one, two, four and eight foxes at a constant density ratio of one fox per square metre. It is not known how many control animals were involved. These studies were said to find that, amongst silver foxes, all groups had a higher growth rate, more activity and, apart from a few biting injuries, there was no significant difference in fur quality or fur damage. Amongst blue foxes, activity levels were highest amongst group-housed animals, and there was no difference in growth rate and fur quality.

Bakken *et al* (1994) suggested that problems arising from group housing systems are mainly restricted to the breeding season; in most published studies insufficient information prevents the assessment of this possibility. Certainly, group housed animals have been reported as attempting to escape as the breeding season approaches (Korhonen and Alasuutari 1994, Korhonen *et al* 1997). Perhaps, if foxes were housed in small groups of closely related individuals in enlarged, complex environments, such as that in Korhonen and Niemelä (1996b), outside of the breeding season, the suggested positive

894 effects of social and physical enrichment would be seen without negative effects on fur
895 quality and reproductive success.
896
897 **Reproduction issues: maternal infanticide, the influence of neighbours and further**
898 **abnormal behaviour in captivity**
899 Killing and injury of cubs is a common problem on fur farms (Bakken 1989, Braastad
900 1990a,b). A survey of all fox farms in Germany found that 45% of silver foxes and 40%
901 of blue foxes failed to breed (Haferbeck 1988 and *pers. comm.*): this figure is
902 substantially higher than the average of 20.5% in the wild (see Lloyd 1980b). However,
903 reports from fur farming organisations, albeit unverifiable, suggest that Haferbeck's
904 figures are much higher than the norm for fox farms. Whilst much reproductive failure in
905 the wild is due to lack of food, farmed foxes are generally well fed. Reproductive
906 failure, when there is adequate opportunity to reproduce, is an indicator of poor welfare
907 (Broom and Johnson 1993).
908
909 Wiepkema (1994) estimated that 10 to 20% of female farm foxes show infanticide at
910 some time but the data upon which this estimate is based are not presented. This is
911 obviously a substantial welfare problem. Amongst farmers, cub-killing has often been
912 thought to arise from stress caused by the farm environment, or vixens with pathological
913 social behaviour (Bakken 1993a,b). However, research now indicates that some vixens
914 may kill and injure their own cubs because of the neighbours alongside which they are
915 housed. In either case, poor welfare of the vixens is indicated and the welfare of the
916 killed cubs may be very poor before death.
917
918 Braastad (1988) showed a relationship between fearful behaviour and poor
919 reproduction. Braastad and Bakken (1993) studied the behaviour of 21 primiparous and
920 18 multiparous vixens. Of 54 dead cubs, 41 had been bitten and probably killed by their
921 mother. Seventeen vixens were categorised as infanticidal. Half of these bit off the tails of
922 their cubs, prior to killing them. Quantitative analysis of behaviour in relation to cubs
923 showed that both infanticidal and non-infanticidal vixens exhibited similar behaviour,
924 including the same amount of cub grooming: the only observable difference was that

infanticidal vixens stood during grooming and appeared more restless in the nest box. Infanticide, therefore, did not appear to be the result of inept breeding behaviour. Neither did it appear that particular disturbances on the farm initiated cub-killing. However, cub-killing was a restricted to certain individuals, with infanticidal vixens repeating their behaviour in later years. Moe (1996) reported that infanticidal vixens showed the most pronounced stress-induced hyperthermia response, a reponse which is readily induced by human proximity.

Studies have shown that infanticidal vixens, or those with lower reproductive success, tend to have lower social status than successfully reproducing vixens (Bakken 1989, 1992, 1993b). In the wild, reproduction is often suppressed in subordinate foxes. Braastad and Bakken (1993) therefore suggested that infanticidal behaviour may be the result of low social status vixens choosing not to reproduce in a given year, only to find that they cannot change their strategy in subsequent years because the social housing conditions on the farm remain static. The suggestion that infanticidal vixens are affected by the presence of their neighbours was borne out in the work of Bakken (1993b) in which 16 vixens which had been infanticidal were physically and visually isolated from other vixens. They then raised significantly more unharmed cubs. Furthermore, Bakken (1993a) found significant variation in infanticidal behaviour according to the social status of vixens' neighbours. In this experiment, cubs were assessed on the basis of their competitive ability (a score of high, medium or low awarded on the basis of the ability to obtain food when repeatedly put in cage with another cub): as adult, these animals were housed in specific relationships to their neighbours. There were no significant differences between the number of cubs born to any group and even isolated vixens lost half of their cubs, however, vixens of low competitive ability killed or injured more cubs than those of high competitive ability. Altogether, of 153 cubs born, 77 were killed or injured by their mothers. Dead cubs had bite marks on their bodies, often with the skull crushed, or half-eaten. Bakken found that vixens of high competitive ability with neighbours of low competitive ability weaned the most unharmed cubs. No vixen of low competitive ability weaned unharmed cubs if she had neighbours of high competitive ability, however, such vixens did wean unharmed cubs when they had neighbours of low competitive ability.

Pedersen (1998) studied reproduction and behaviour in silver fox vixens kept together and found a high occurrence of infanticide, most often by the subordinate vixen. The two vixens sometimes both produced cubs but there was also failure to reproduce, the exact mechanism being unclear.

These studies raise two important issues. Firstly, it is clear that the physical placement of the cage within the housing system can have a highly significant effect on welfare. Given the demonstrated effects of status-linked infanticide, and the fact a vixen's status is rarely known, it seems highly likely that a proportion of low status vixens under standard farm conditions will always have poor welfare and kill or mutilate their own cubs. Secondly, cub mortality because of infanticide exceeded 50% in the study by Bakken (1993a). Braastad and Bakken (1993) reported that the probability that a cub with a primiparous mother would be killed was 37%. These figures seem extremely high, and yet no papers other than those reviewed in this section mention the incidence of infanticidal behaviour. Indeed, although it is reported that reproduction amongst farmed foxes is problematic (Bakken *et al* 1994), it is not known how reproductive success varies between and within standard farming systems, nor what the average rate of infanticide is on farms beyond the limited information given here. Accurate data are difficult to obtain on commercial farms because dead pups are usually eaten, whatever the cause of death.

In terms of other abnormal behaviours, almost no mention is made in the literature of stereotyped behaviour, with the exception of Jeselnik and Brisbin (1980) in relation to two captive foxes, and remarks by Braastad (1992, 1993). Braastad (1993) commented that in a study of silver fox vixens, all animals persistently performed digging movements on the wooden floor of the breeding box prior to delivery. During the last pre-parturient day, vixens "excavated" for a total of 102 minutes, in long bouts of several minutes. Some silver fox vixens also performed stereotyped digging which may have been motivated by hunger. Braastad (1992) commented that stereotypies in foxes have not been systematically studied.

Thus it appears that the extent of abnormal behaviours, which indicate poor welfare, such as infanticide and stereotypies is not sufficiently documented in relation to fox farms.

Whether cubs, which, in the wild, often remain in their natal territory until at least six months of age, would benefit from being left with the vixen for a longer period is unknown. The effects of olfactory or auditory stimuli from conspecifics are unknown, but it seems likely that animals with advanced usage of such senses will be affected in ways which are beyond the immediate notice of humans.

**Conclusions**

1. Extensive studies of wild foxes reveal that they are complex animals. They spend a long time (up to six months) rearing their cubs, they travel long distances and red foxes make patterned use of large home ranges. Social behaviour is wide and varied, and social status strongly affects group relations and productivity. Males, and non-breeding vixens, play a role in rearing the cubs. Reproduction is evidently controlled by complex factors. Foxes seek cover regularly and may use several dens. Those wary of conspecifics may attempt to avoid leaving scent trails, and the relative importance of scent-marking of paths and caches via urine or gland secretions cannot be assessed. Foxes are probably capable of a high degree of learning, and show evidence of lasting memory, and possibly, use of cognitive maps. On fox farms they are almost always kept in small, barren, contiguous cages with no physical enrichment, other than a wooden nest box when whelping and sometimes a wire-mesh platform. They live in a largely static social environment determined haphazardly. They have no opportunity to adjust their distance or take shelter in relation to aversive stimuli, such as the presence of conspecifics or humans. The effects of sensory variables, such as olfactory and auditory cues, on foxes housed in large numbers in farm sheds are unknown.

2. There is clear evidence from research on fox welfare in relation to housing that farmed foxes show a considerable degree of fear, both of humans and in general behaviour, that the barrenness of cages is a significant problem for the foxes and that

farmed foxes can have substantial reproduction problems. There is clear evidence that the welfare of farmed foxes in the typical bare, wire-mesh cages is very poor.

3. A long-term selective breeding experiment on silver foxes in Siberia appears to have successfully produced foxes that are less fearful under farm conditions. Some comparable experimental results have been obtained in Europe, but the programme is long-term and significant results are not yet available.

4. Studies of early handling of fox cubs make a strong case that this treatment can have a beneficial effect on long-term welfare in terms of reducing fearfulness. Handling which occurred twice daily for three weeks post-weaning and involved firm handling (in contrast to fondling) and brief removal into another cage, had a long lasting effect on fear responses to a human reaching for the fox, and to novel objects. Research suggested that non-handled foxes were chronically stressed. Given that foxes on farms are frequently removed from their cages by humans, fear of humans is a significant welfare problem. Treatments which can reduce such fear are to be recommended, but it is questionable whether farmers will give the time required to do this.

5. Increases in the size of the barren cage, without a consequent increase in the complexity of the environment, do not appear to benefit farmed foxes. However, larger space allowances for foxes can make real enrichment possible.

6. Some studies have shown that year-round use of a nest box can have significant benefits for farmed foxes: others indicate that they are not used often by foxes. Nest boxes are likely to enrich the environment even if they are not used. It is clear that the addition of viewing platforms to cages provides environmental enrichment for the majority of foxes. Platforms of appropriate size have been used by captive foxes of both species for biologically appropriate behaviours, and they can evidently increase the complexity of the environment for foxes. Nonetheless, insufficient attempts have been made to add further physical enrichment and complexity to the cage system of singly housed foxes.

7. It seems likely that the opportunity to view the surroundings is an important aspect of captive fox housing, and the fact that occurrences in the wider shed environment (e.g. visual exposure to humans, greater sensory input) can affect foxes has been proven. It may well be the case that daily activities and various seemingly innocuous events have an unnoticed effect on captive foxes. Traditional fox cages are up to one metre high and any shelf is therefore unlikely to be high enough to provide an adequate view point. Much more elaborate cages, or systems of linked cages, rather than simple cages, would be much more likely to provide for the needs of foxes.

8. The traditional wooden nest box, provided for vixens during the breeding season, can probably be improved.

9. Experiments involving group housing of animals in large enclosures or complex cage systems have shown some beneficial effects and some detrimental occurrences. It may be possible to overcome the detrimental effects if foxes are not group-housed during the breeding season. In such studies, insufficient account has been taken of the social problems likely to be inherent in housing unrelated foxes together.

10. The extent of stereotyped behaviour in farmed foxes is not adequately documented.

11. The incidence of abnormal behaviours in farmed silver foxes is cause for serious concern. The killing and injury of cubs (tail removal, biting) by their mothers has been reported as a common problem on fox farms, and yet comparatively few studies have examined this issue. The extent of infanticide on farms is not known. Experiments have shown that visual isolation of low status females and manipulation of the social status of neighbours can lead to significantly lower incidence of cub-killing in typically infanticidal vixens. This strongly suggests that reproductive performance is inhibited and infanticidal behaviour enhanced among many low status females on farms today.

12. A combination of selective breeding, appropriate early handling and major changes in cages and management so as to provide for the needs of the foxes will significantly improve welfare. However, in the light of the cautionary comments made in Conclusions 3, 4, 6, 7, 9 and 11, it is clear that the desirable major improvements in welfare will be difficult to achieve.

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