EFFECTS OF GROUP HOUSING IN AN ENLARGED CAGE SYSTEM ON GROWTH, BITE WOUNDS AND ADRENAL CORTEX FUNCTION IN FARMED BLUE FOXES (*ALOPEX LAGOPUS*)

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Abstract *Animal Welfare 2000,* ***9:*** 403-412

It has been claimed that the present farming environment does not meet foxes' needs for social behaviour. In this study we measured the welfare of farmed blue foxes, Alopex lagopus, *housed in two different social and spatial conditions: i) traditional housing (group T) where a male and a female cub were housed together and their vixen alone in standard (1.2m*^{2}*) fox cages; and ii) family housing (group F) where a vixen and her five cubs were housed together in a connected six-cage system (7.2m*^{2}*). Production-related welfare parameters (weight gain and the incidence of bite wounds on fur) as well as physiological ones (adrenal mass and serum cortisol response to ACTH administration) were measured in these two groups.*

No differences were found in any of the measured parameters between the vixens housed in traditional and family units. In cubs, there was less difference between the sexes in weight gain in group F than in group T, and a significantly lower weight gain was evident only in group T female cubs. The serum cortisol level in response to an ACTH challenge was higher in group T cubs and independent of the sex of the animal, while heavier adrenals were observed in group T male cubs only. We conclude that the enlarged cage system combined with group housing had some beneficial effects on the measured performance- and welfare-related indicators in blue fox cubs.

Keywords: *animal welfare, behaviour, bite wounds, fur farming, social behaviour*

Introduction

The arctic fox, *Alopex lagopus*, occurs in two colour phases, white and blue. In commercial fur production, the blue phase (blue fox) is the most common, whereas in natural conditions the distribution of white and blue phases differs regionally (Chesemore 1975). In the wild, the arctic fox is an opportunistic carnivore living in the northern tundra area, a region with harsh climate conditions and food scarcity both within and between years (Chesemore 1975). The availability of food influences the distribution and group size of arctic foxes (Hersteinsson & Macdonald 1982) as well as the time at which cubs abandon their natal den site (Frafjord 1992). Therefore, depending on their habitat, they can be considered as solitary (Anthony 1997), or social but territorial (Hersteinsson & Macdonald 1982), or territorial with overlapping home ranges within families (Eberhardt *et al* 1982). Garrot *et al* (1984) reported that even within family groups, the most prevalent behavioural category displayed by the adults was non-social. This non-sociality within families was construed as reflecting the solitary nature of the arctic fox. However, flexible and complex social organizations (Wakely & Mallory 1988) with territories that support more than an adult pair of foxes have also been reported in some arctic fox populations (Hersteinsson & Macdonald 1982).

Irrespective of the social organization of the arctic fox, competition for food will probably occur in all habitats that they occupy. This competition will probably affect the production and survival rate of arctic foxes, especially that of pups. Hiruki and Stirling (1989) found that survival rates of arctic foxes were affected by the availability of prey and were 58 per cent and 23 per cent for adult and juvenile arctic foxes respectively – but in some years survival rates as low as 3 per cent were found for juvenile foxes. Macpherson (1969) suggested that this severe pup mortality might be caused by sibling aggression, and assumed that when food is a limiting factor, the largest pups are most likely to survive. However, this theory was not supported by Garrot *et al* (1984) who found only minor degrees of aggression among pups.

Under farm conditions, blue foxes are housed in outdoor sheds in wire-mesh cages. After parturition (May–July), a vixen and her cubs stay together until the cubs are weaned (the cubs being approximately 8 weeks old). Thereafter, adult foxes are housed alone and the cubs either alone or in pairs (most commonly male:female pairs).

Throughout the history of fox farming, fox farmers have concluded that the pair housing of cubs is superior to other housing conditions, although there is no scientific evidence to support this. To clarify the effects of housing environment on welfare and production-related parameters, experiments have been conducted on housing blue foxes in soil-floored enclosures under different social and spatial systems (Korhonen & Alasuutari 1994; 1995; Korhonen & Niemelä 1996). These studies have shown that blue foxes establish a fixed social group organization quite rapidly, and that excessive aggressiveness outside the breeding season is uncommon since the animals seem to be aware of their rank in the social hierarchy. Under commercial fur production conditions, where large numbers of offspring and good fur quality are expected, there are problems associated with group housing in soil-floored enclosures. The existence of non-breeding helpers within groups (Hersteinsson & Macdonald 1982; Kullberg & Angerbjörn 1992), fierce fights (especially during the breeding season), and poor fur quality (Korhonen & Alasuutari 1994; 1995; Korhonen & Niemelä 1996) create problems which may well outweigh the enrichment value of this system.

However, intraspecific aggression may be alleviated if group housing is limited (except during the breeding season), and soiling of the fur can be prevented by a wire floor. Therefore, in the present study, family groups of blue foxes were housed from weaning until pelting (August–December) in wire-mesh cages. The aim of the study was to compare certain physiological and production-related welfare parameters between: i) blue fox cubs raised in traditional systems (ie as male:female pairs with their maternal vixen housed separately and alone); and ii) blue foxes raised as family groups in an enlarged cage system.

Materials and methods

Approval to conduct this scientific study at the Research Station of the Institute of Applied Biotechnology (University of Kuopio, Finland) was granted by the Institutional Animal Care and Use Committee of the University of Kuopio, Finland (Licence No 98-39). Under this approval of the research protocol, the methods used for animal care as well as for euthanasia of the animals were in accordance with the recommendations contained in the *European Convention for the Protection of Animals Kept for Farming Purposes* (European Convention 1998).

Animals and cage construction

A total of 14 adult vixens, 35 male and 28 female blue fox cubs (born May–June) were included in the experiment. At the time of weaning, when the cubs were about 8 weeks old (July–August), the animals were divided into two different housing conditions: traditional housing (group T) and family housing (group F). There was no significant age difference between the experimental groups (Mann-Whitney *U* test), but age differences between the families within the experimental groups existed ($P < 0.001$ for both groups, Kruskal-Wallis test).

In the traditional housing treatment (group T), seven vixens were housed singly, and their cubs (two male and two female from each vixen) were housed as 14 male:female sibling pairs in standard wire-mesh cages measuring 115x105x70 cm. The floor area for each group T vixen and cub was $1.2m^2$ and $0.6m^2$ per animal, respectively. No furniture other than a resting platform (105x30 cm) was available for group T foxes.

In the family housing treatment (group F), seven family units each consisting of a vixen and her three male and two female cubs, were formed by removing and relocating extra members of the family at the time of weaning. The cage system for each family unit consisted of six standard fox cages joined by openings (20x20 cm) through the walls between the adjacent cages. This formed an enlarged cage system with a total floor area of $7.2m^2$, ie $1.2m^2$ per animal. In group F, there was a resting platform (105x27 cm) in each cage and an opaque concealment screen (71x42 cm) was mounted under the platform in every second cage.

All the animals were fed with freshly mixed fur animal feed (Ylä-Karjalan Rehu Ltd, Valtimo, Finland) twice a day (at c 0900h and 1400h) until mid-September, and once a day thereafter. In group T, feed was delivered onto one feeding tray, while in group F feed was delivered onto two trays (in cages 2 and 4) until the end of September and thereafter onto three trays (in cages 2, 4 and 6). Water was available *ad libitum*. The health of the animals was checked daily and any injured or sick animals were removed and treated.

Measured parameters

Physical measurements

Animals were weighed once every three weeks (ie six times) during the growing season (August–December). At pelting, the number of bite wounds on the skins of the foxes and the number of foxes with such bites was counted. At autopsy, both adrenals were removed and weighed.

Response to disturbance

A disturbance test (see, Rekilä [1999]) was carried out by the same observer on five occasions (10 August, 1 September, 21 September, 10 October and 2 November) during the experimental period. In the test, the observer entered the shed, walked calmly along the corridor to the middle of each consecutive six-cage system (group F) or each cage (group T), and recorded the location of each individual after 30s. Any animal located in cage 3 or 4 (group F), or in the front part of the cage (group T), after the 30s period was considered to be 'near the observer'.

ACTH challenge

Since the measurement of baseline levels of cortisol is subject to errors, due to diurnal, seasonal and short-term changes and a rapid response to the sampling procedure, an adrenocorticotropic hormone (ACTH) challenge test can been used to assess the long-term effects of environmental factors (see, Fraser & Broom [1990]). According to the hypothesis behind this test, an animal using its adrenal cortex frequently is likely to have higher levels of the cortical enzymes needed for cortisol synthesis than an animal that has to rely on its adrenal cortex less often. Therefore, injection of a large dose of ACTH will evoke higher serum cortisol levels in animals that have been under more stress, eg pigs housed at higher stocking densities (Meunier-Salaun *et al* 1987) or red deer not habituated to humans (Goddard *et al* 1994).

At pelting time in December, the foxes were caught in their home cages and injected intramuscularly with ACTH (0.3ml animal^{-1} synthetic $ACTH_{1-24}$, Synacthen-Depot; Ciba, Finland). After injection, all foxes were placed singly into a smaller cage (70x35x35 cm), and, 2h after injection, they were euthanized by electrocution (Foxstop 1; Evikoje Ltd, Evijärvi, Finland) according to the methods recommended by the Standing Committee of the *European Convention for the Protection of Animals Kept for Farming Purposes* (European Convention 1998). Blood samples (5ml) were drawn immediately after death with cardiac puncture and stored at -20°C until assayed. Serum cortisol level (nmol l^{-1}), as a maximum response to ACTH administration (Rekilä *et al* 1999), was analysed by a competitive immunoassay technique (Coat-A-Count® Cortisol Assay; Diagnostic Products Corporation, Los Angeles, USA).

Statistical analyses

Due to the low number of individuals within families, differences in the cubs' hypothalamic-pituitary-adrenal (HPA)-axis activity and in body weight between the families within the experimental groups was analysed by non-parametric Kruskal-Wallis tests using SPSS©, version 7.5 (SPSS Inc, Chicago, USA). The data from both sexes were pooled, again due to the low number of individuals within families. Changes in the proportion of animals recorded as near the observer during the disturbance tests were analysed separately for vixens and cubs in both experimental groups by the non-parametric Cochran's *Q* Test, using a dichotomous variable of the animals recorded as near the observer or far from the observer

Since the number of bite wounds in the skin was not normally distributed, differences in the mean number of bite wounds between the sexes and experimental groups were analysed using the non-parametric Mann-Whitney *U* test and differences in the number of animals with bite wounds using a chi-square test. Other measured parameters were normally distributed, and subjected to a one-way analysis of variance (ANOVA). Results from the vixens were analysed separately from the cubs. Pearson product-moment correlation coefficients between the serum cortisol levels 2h after ACTH administration and adrenal masses were determined separately for the vixens and the cubs of each sex and experimental group.

All results are expressed as mean ± SD values. The level of statistical significance was set at $P < 0.05$.

Results

In group T, one female cub was found dead in late August. In group F, one female cub was found injured in late September, and was then removed from the family unit.

During the growing season, there was no significant change in the percentage of group F and group T vixens recorded as near the observer in the disturbance test (group F – 28.6%, 42.9%, 14.3%, 28.6% and 42.9 %; group T – 28.6%, 28.6%, 28.6%, 14.3% and 14.3 % on 10 August, 1 September, 21 September, 10 October and 2 November, respectively). In contrast, the proportion of cubs recorded as near the observer increased in both groups with the advancing autumn (group F – 8.6%, 11.4%, 14.3%, 17.6% and 35.3 %; group T – 7.1%, 14.8%, 18.5%, 29.6% and 40.7 %, respectively; $P < 0.05$ for both groups).

In the cubs, there were significant between-litter differences within group T in the mean body weights of the family members until late autumn ($P < 0.001$ in August and $P < 0.01$ in September and October) but not in November and December. No significant differences between the litters were found in the mean serum cortisol levels after the ACTH challenge, or in the mean adrenal masses in group T. In group F, mean body weights differed between the litters throughout the experiment ($P < 0.001$ in August and September, $P < 0.01$ in October, $P < 0.05$ in both November and December). Furthermore, a significant difference between the group F litters was found for the mean serum cortisol levels ($P < 0.01$) but not for the mean adrenal masses.

There were no statistical differences between group T and group F vixens in body weight during the experiment (early August: 6.5 ± 0.9 kg vs 6.3 ± 1.0 kg; December: 11.4 ± 1.6 kg vs 10.7 ± 2.3 kg, respectively; ns). There was no significant difference between group T and group F vixens in the serum cortisol levels 2h after ACTH administration; and there was no significant difference between the groups in adrenal masses (Table 1). Furthermore, there was no significant correlation between serum cortisol levels and the adrenal masses of vixens in group T (r = -0.220, ns) or group F (r = 0.559, ns).

Table 1 Comparison of serum cortisol levels (mean ± SD) 2h after an ACTH challenge and of total adrenal masses (mean ± SD) among blue fox vixens and cubs in traditional (group T) and family (group F) housing systems. (ns – not significant.)

	Group T	Group F	*P* value
Cortisol level (nmol l^{-1})			
Vixens	291 ± 36 (n = 7)	299 ± 30 (n = 7)	ns
Cubs			
Male	305 ± 37 (n = 14)	264 ± 42 (n = 21)	0.006
Female	320 ± 43 (n = 13)	276 ± 41 (n = 13)	0.014
P	ns	ns	
Adrenal mass (mg)			
Vixens	355 ± 65 (n = 7)	317 ± 41 (n = 7)	ns
Cubs			
Male	385 ± 39 (n = 14)	333 ± 70 (n = 18)	0.018
Female	311 ± 53 (n = 11)	316 ± 36 (n = 13)	ns
P	0.001	ns	

In the cubs, from early August until late September, there were no significant differences in body weight between the sexes or the experimental groups (Figure 1). Group F males were heavier than group T males in October ($P < 0.05$) but not later in the year; while group F

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females were heavier than group T females from October onwards ($P < 0.05$, $P < 0.01$ and $P < 0.001$ in October, November and December, respectively). Within the experimental groups, group T males were heavier than group T females from November onwards ($P < 0.01$ and $P < 0.001$ in November and December, respectively); whereas in group F only a tendency in this direction was evident in December ($P = 0.074$).

Serum cortisol levels after ACTH administration were higher in group T cubs than in group F cubs, irrespective of sex (Table 1). Within the experimental groups, no significant differences between the sexes were found. Group T males had significantly heavier adrenals than group F males, while no such difference was found in the females (Table 1). Group T males also had heavier adrenals than group T females, whereas in group F there was no significant difference in adrenal mass between the sexes. No significant correlations were found between serum cortisol levels and adrenal masses in group T males, group T females, group F males or group F females ($r = 0.224$, $r = 0.390$, $r = -0.091$, $r = -0.081$, respectively; all ns).

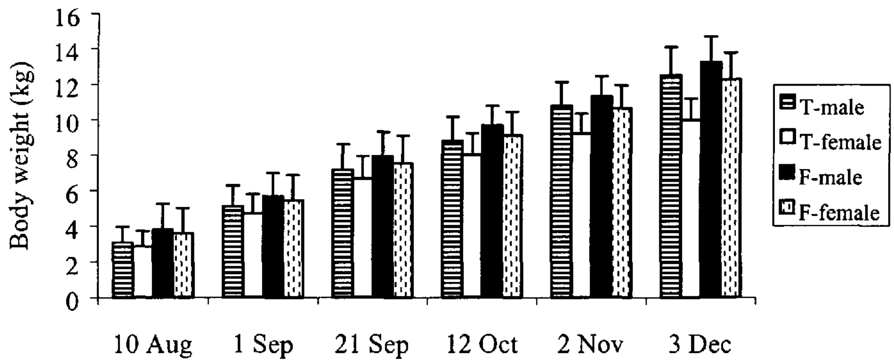

Figure 1 **Comparison of mean (+ SD) body weights in blue fox cubs housed during the growing season in traditional (group T) and family (group F) housing systems.**

There were no significant differences between the experimental groups in the number of bite wounds on the skin for vixens or cubs; or between the sexes for cubs within the experimental groups (Table 2). Furthermore (see Table 2), there were no significant differences between the experimental groups in the number of animals carrying bite wounds (vixens – chi-square = 0.000, *df* = 1, ns; male cubs – chi-square = 0.305, *df* = 1, ns; female cubs – chi-square = 0.650, *df* = 1, ns); or, in the cubs, between the sexes within the experimental groups (group T – chi-square = 1.899, *df* = 1, ns; group F – chi-square = 0.007, *df* = 1, ns).

Discussion

Under farm conditions, blue foxes are fed daily to ensure good growth and fur quality for all individuals. Therefore, there should be no competition for food, and the only difference in body weight should be between males and females because of sexual dimorphism (Wakely & Mallory 1988). It could be argued that social stress might be more pronounced in groups

Table 2 **Number of bite wounds (mean/median) and the number and percentage of animals with bite wounds among blue fox vixens and cubs housed in traditional (group T) and family (group F) housing systems. (ns – not significant.)**

	Group T	Group F	*P* value
Number of bite wounds (mean/median)			
Vixens	2/0	0/0	ns
Cubs			
Male	2/0	1/1	ns
Female	4/1	6/1	ns
P	ns	ns	
Number of animals with bite wounds (number/per cent)			
Vixens	2/28	2/28	ns
Cubs			
Male	6/43	11/52	ns
Female	9/69	7/54	ns
P	ns	ns	

of several animals than in pair-housed animals, and that this stress could lead to impaired growth and to a larger inter-individual variation in body weight. However, our results show that in larger family groups blue fox cubs gained weight just as well, or even better, than cubs housed in pairs. Furthermore, sexual dimorphism in body weight, which was observed in pair-housed cubs, was reduced in the larger social groups.

In wild-born arctic fox cubs that were raised in enclosures, males dominated females, especially at feeding times and at the beginning of the growing season (Wakely & Mallory 1988; Frafjord 1993). Under these circumstances, a lack of agonistic interactions when the cubs grew older, might be due either to a stable hierarchy or to a lowered motivation to fight for food since the foxes would have become accustomed to a regular feeding pattern. In our study, the difference in body weight between the sexes in group T but not in group F cubs indicated that social competition was evident in the former. One reason for this lower social competition in group F might be that feed was delivered onto two or three feeding trays, allowing lower ranking individuals, ie females, easier access to feed compared to male:female pairs which were provided with one food tray only. The observation that social hierarchies in a blue fox pack are most pronounced at feeding time (Wakely & Mallory 1988), supports this conclusion – but cannot explain why each of the three male cubs within the family groups did not dominate a feeding tray of its own. However, one must bear in mind that in late autumn, ie once the animals were fully grown and had reached their final body weight, between-litter differences in body weight were evident in group F cubs but not in group T cubs. This indicates that the effect of littermates on each individual cub may be more pronounced in larger (family) groups than in pair-housed cubs; and that when interpreting welfare-related results one should not consider just an individual fox but a whole family.

In addition to influencing growth performance, social stress can affect the activity of the HPA-axis, leading to an increase in cortisol secretion from the adrenal cortex (see, Fraser & Broom [1990]) and adrenal hypertrophy (Selye 1950). In our study, the levels of cortisol in response to ACTH administration were higher in group T cubs, independent of sex. However, heavier adrenals were observed only in group T male cubs, whereas lower weight gain was evident only in group T female cubs. The heavier adrenal masses in group T male

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cubs could perhaps be attributed to social stress – which affects not only the most submissive but also the most dominant animals (Bekoff 1977). On the other hand, group T female cubs were the lightest animals, with the highest serum cortisol levels and could have been stressed by the presence of a heavier, and probably dominant, male cub in their housing system. Again, as with the body weight, between-litter differences in cortisol levels were greater in group F than in group T, indicating the importance of littermates when housing cubs in larger groups.

It is not clear why different welfare indicators reacted differently in the male and female cubs. The lack of correlation between the cortisol level values and adrenal mass is not a new finding: it has been demonstrated in rats (Heroux 1960) and, more recently, in silver foxes (Pedersen 1994; Rekilä *et al* 1999). Our results emphasize the fact that no single parameter represents a complete measure of animal welfare, but a combination of several indicators is always needed (Rushen 1991; Broom & Johnson 1993). This conclusion, however, does not solve the problem because it only leads to the next question: which combination of indicators is the best?

Unlike their cubs, different social and spatial conditions had no effect on body weight, serum cortisol response to ACTH administration or adrenal mass in adult vixens. The earlier experiences (Pedersen 1994) and the age of these animals might explain this lack of effect: the vixens were already fully grown and had faced several challenges including mating, pregnancy, and solitary, pair and family life. In future studies evaluating the welfare effects of different housing designs/environments, the relative insensitivity of adult animals, in contrast to juveniles, should possibly be taken into account.

If group housing is considered a viable, alternative way of raising blue foxes, the production-related parameters should not be overlooked. No significant differences were found between the experimental groups in the number of bite wounds on the skin of individuals or in the number of animals with bite wounds. However, it should be borne in mind that it was not possible to be sure whether the bite wounds on the vixens were fresh (inflicted by their cubs of that year) or old (inflicted earlier by their littermates or their mother). Although the wounds were not severe and the number of bite wounds per individual was most commonly either zero or one, a high number of animals (over 50%) had some kind of bite wound. However, this was not surprising since in wild red foxes, *Vulpes vulpes*, another rather solitary canid species, bite wounds are common in nature where there is 'an unlimited space available' and in dense populations up to 7 per cent of individuals succumb in fights with conspecifics (Harris & Smith 1987).

Conclusions and animal welfare implications

We conclude that the enlarged cage system combined with group housing had some effects on the blue foxes in our study. All the welfare-related indicators, ie body weight, serum cortisol level after ACTH administration and total adrenal mass, indicated that family-housed blue foxes were, in general, less stressed than the foxes housed in traditional systems. However, since the differences in the mean body weight and in the HPA-axis function were more pronounced between the families in group F than in group T, one must not overlook the effect of between-litter differences in silver foxes housed as families, ie that some families 'do better' than others.

When considering the overall welfare of farmed animals, it should also be borne in mind that they must become accustomed to the presence of humans (Fraser & Broom 1990). Although some such habituation appeared in group F cubs during the growing season, over half of the foxes in group F fled from an approaching human to the furthest ends of their home-cage system – even in November. On the one hand, since the foxes' fear of humans is considered to indicate impaired welfare (Pedersen 1994), an enlarged cage system has its disadvantages too. On the other hand, the larger space with the possibility to flee in an aversive situation may promote a sense of control which, in turn, is considered important for the welfare of animals (Broom & Johnson 1993). It was not possible to draw any final conclusions as to whether differences in the social composition or in the space per animal or a combination of these two factors was the actual reason for the observed differences in the measured welfare parameters. Hence, different space allocations, foxes which have been habituated to humans (ie handled [Pedersen 1994]) or foxes selected for confident behaviour (Rekilä *et al* 1999) should be included in future studies on the effects of group housing in blue foxes.

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