THE EFFECTS OF ELEVATED PLATFORMS AND CONCEALMENT SCREENS ON THE WELFARE OF BLUE FOXES

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Abstract *Animal Welfare 2001, **10:** 373-385*

Nowadays in Europe, farmed blue foxes are kept for most of the year in wire-mesh cages furnished with a platform for resting and observing the environment but without any opportunity for hiding from other foxes or from man. We studied the welfare effects of providing an elevated platform and two types of concealment screens in singly housed juvenile male blue foxes (n = 46) from August to December. The foxes were allocated to four experimental groups: group C had no furnishing in the cage, group P had a platform in the cage, group U had a platform and a concealment screen in the cage, and group O had a platform and a concealment screen on the outer wall of the cage. The blue foxes with platforms (groups P, U and O) spent the majority of their time on the platforms both when their cages were approached by man and as revealed by 24 h video recording. The 24 h recordings revealed that the foxes tended to avoid those locations in the cage where the screens obstructed their view (groups U and O); however, when the screens allowed the foxes to hide from an approaching man (group U), they were used for that purpose to some extent. There were no differences between the four groups in terms of growth, increase in rectal temperature after an acutely stressing situation, adrenal size, or fearfulness. The urinary cortisol:creatinine ratio showed that foxes in group U may have been less stressed than those in groups P and O in September, but no differences were observed in October. The concealment screens of group U may have improved the welfare of these blue foxes.

Keywords: *animal welfare, blue fox, concealment screen, elevated platform, fear, fur farming, resting platform*

Introduction

Farmed foxes have traditionally been raised in unfurnished wire-mesh cages. Breeding females only are provided with nest boxes for whelping in the spring (CEC 1990). Thus, the foxes do not normally have access to separate areas for resting or for concealing themselves. The provision of elevated platforms (also known as resting platforms or shelves) and year-round nest boxes has been proposed as a way of enriching the cage environment and improving foxes' welfare, and platforms are already becoming established in European fur farms (European Convention 1998).

Blue foxes (*Alopex lagopus*) may spend, on average, more than 40 per cent (Korhonen & Niemelä 1996) or even up to 60 per cent (Mononen *et al* 1993) of their daily time on platforms. Mononen (1996) has reviewed the large amount of data on the extent of platform

use by farmed blue foxes and the factors affecting their use (see Mononen 1996, pp 27–31). He concluded that the platforms seem to function both as resting places and as observation places that offer an unrestricted view (see Mononen 1996, pp 34–41).

The average time spent in nest boxes has varied between studies from no use at all (Korhonen *et al* 1994) or little use (Alasuutari & Korhonen 1992) in large ground floor enclosures to 12 per cent (Mononen *et al* 1996a) or more than 50 per cent (Jeppesen & Pedersen 1990) of daily time in cages. Many blue foxes hide in nest boxes when they are disturbed (Pedersen & Jeppesen 1993). If blue foxes are offered the opportunity to hide, they take advantage of it and, as a result, do not habituate to people, which may thus increase these foxes' fearfulness (Harri *et al* 1998). A structure that is less closed than a nest box, such as a concealment screen, would offer the benefit of providing the opportunity to hide from man and from neighbouring foxes but would enable the foxes to habituate to the presence of man.

Although preference tests show that observation and hiding places do have some importance for blue foxes, elevated platforms or year-round nest boxes have not been found to have any clear effects on their welfare as measured by growth, reproductive performance, physiology or behavioural test performance (Jeppesen & Pedersen 1990; Harri *et al* 1995; Korhonen & Niemelä 1995; Rekilä *et al* 1996). In the present study, the welfare effects of elevated platforms and concealment screens (ie less enclosed spaces that still allow the opportunity for hiding) were assessed in juvenile male blue foxes. Welfare was assessed using growth, stress physiology and behavioural measurements. Furthermore, foxes' preferences for position within their cage were incorporated into the interpretation of the results.

Methods

The experiment was carried out on the Juankoski research station of the University of Kuopio (63.02°N, 28.22°E), between August and December 1997 (Table 1). The study was approved by the Institutional Animal Care and Use Committee of the University of Kuopio (Licence no. 97-46).

Table 1 Timetable of the experiment.

Week No.	Month	Procedure(s)
33	Aug	Blue foxes into experimental cages, body weight
35	Aug	Walk test
36	Sep	Walk test
37	Sep	Walk test
38	Sep	Walk test, first 24 h urine samples
39	Sep	Walk test, first 24 h video-recording
40	Sep–Oct	Walk test, first 24 h video-recording
41	Oct	Walk test, body weight
42	Oct	Walk test, second 24 h urine samples
43	Oct	Feeding test
44	Oct	Walk test, body temperature test
45	Nov	Second 24 h video-recording
46	Nov	Second 24 h video-recording
49	Dec	Pelting: body and organ weights, other body measures

The experimental animals — forty-eight juvenile male blue foxes — were kept in both rows of a two-row shed in traditional fox cages measuring 105 x 115 x 70 cm (l x w x h). The animals were singly caged during the experiment. The foxes were from 13 litters born in May or June. Twelve animals were allocated to each of four experimental groups. Brothers or half-brothers were allocated randomly but evenly to the four groups. There was no difference in the age distribution of the cubs between the groups. The four groups had various cage furnishings (Figure 1). The control group (C) had a cage without any furnishing. The platform group (P) had a platform (manufactured by Tammet Oy, Kirkkonummi, Finland) measuring 105 x 28 cm (l x w) mounted 25 cm from the cage ceiling. The platform was made of plastic-covered wire mesh and the bottom of the platform was slightly depressed longitudinally. Group O cages also had the platform, and in addition had an opaque hardboard screen (61 x 46 cm, w x h) attached to the outer wall of the cage below the platform, so that a fox could hide in the rear corner, under the platform, from anyone approaching from outside the shed. Group U cages had the platform and an opaque screen (wire-mesh-covered plywood) attached between the edge of the platform and the cage floor. The screen measured 71 x 42 cm (w x h) and the fox was able to move behind the screen into the tunnel-like space under the platform via the openings (18 x 43 cm, w x h) at both ends of the screen.

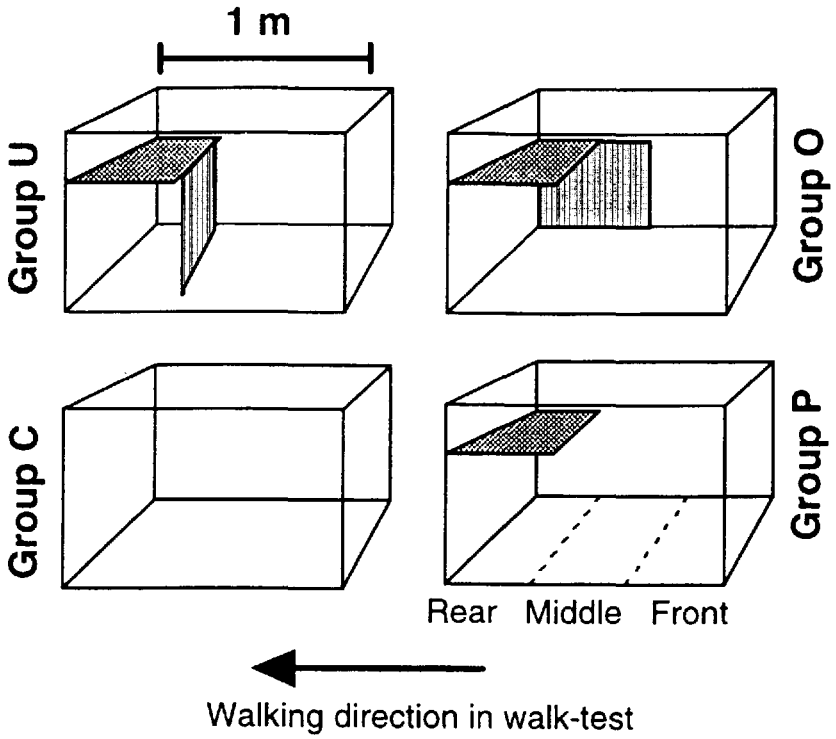

Figure 1 **A schematic drawing of the experimental cages.** The four imaginary sections used in determining the position of the blue foxes during the walk tests and while analysing the videotapes are indicated in the P cage. Note that 'rear' means under the platform in groups P, O and U. One other possible position in these three cages was 'on the platform'. See text for further details.

The order of a basic block of cages was NNUOPCNNCPOU, where N is a non-experimental blue fox inhabiting a cage with a platform but without a concealment screen. These blocks were repeated three times in both cage rows of the shed to avoid any position effects. The reason for this block-arrangement of cages and for using non-experimental animals was to minimise and to balance the effects of the concealment screens on the view from the neighbouring cage in the experimental groups. Furthermore, the N animals were used to increase the distance between the experimental animals and thereby to reduce the possible disturbance caused by the temperature measurement procedure (see below) to the foxes still to be measured.

The extent of the use of different parts of the cage in the presence of man was recorded by an observer calmly walking along the corridor of the shed and recording each animal's position in its cage at the precise moment that the observer was at the front corner of the cage. This test, rather similar to the 'human test' in Korhonen & Niemelä 1996, is referred to as the 'walk test'. The approach was always from the same direction (see Figure 1). These walk tests were performed nine times a week, at 0900h, 1100h and 1300h on Monday, Wednesday and Friday. The foxes were fed with fresh fox feed made by a local feed kitchen (Koillis-Savon Rehu Ltd, Juankoski, Finland). The feed was delivered at 1000h and 1400h until mid-September, after which the foxes were fed only at 1000h. The walk tests were performed for nine weeks (Table 1). For each animal, the percentage of observations (out of the total number of observations) was calculated for each of four cage locations: in the front, in the middle or in the rear section of the cage, or on the platform. Note that 'rear' means under the platform in groups P, O and U (Figure 1).

The behaviour of the foxes was video-recorded for 24 h twice during the course of the study (Table 1). The video equipment was the same as that used in Mononen *et al* (1996a). Videogram frequency was 1.25 frames s^{-1}. Each cage was lit with a dim red light (25W), which permitted video-recording at night. The tapes were analysed using instantaneous sampling (Martin & Bateson 1993) with 5 min sampling intervals for three behavioural categories: resting (asleep or awake), sitting, and locomotion (all other behaviours). The location in which these behaviours were performed was also recorded according to the four areas indicated in Figure 1.

Twenty-four-hour urine samples were collected twice (Table 1) using funnels that were mounted below the cages. The collection of the samples was always begun immediately after mounting the collector funnels below the cages. The mounting procedure meant that there was extra human activity in the shed for more than one hour just before the 24 h sample collection period started. The urine samples were analysed for cortisol (nmol l^{-1}; Coat-A-Count Cortisol Assay by Diagnostic Products Corporation, Los Angeles, CA, USA) and creatinine (mmol l^{-1}; kinetic Jaffe's reaction), and cortisol:creatinine ratios were calculated.

In the feeding test, which is considered to measure animals' fear of man (Rekilä *et al* 1997a), a blue fox was given its daily portion of feed on the top of the cage, and the person feeding the animal remained in front of the cage for 20 s and recorded whether or not the animal ate. The test was repeated five times during one week (Table 1), and each animal's behaviour was scored as the number of tests (out of a total of five) during which it ate. The fox's behaviour in the first feeding test was also analysed separately, because it was in this first test that the foxes were least habituated to the test procedure.

In the temperature test (Table 1), a fox was caught in its home cage and its rectal temperature measured using an Ellab DU 3S thermometer (Ellab A/S, Copenhagen, Denmark) with accuracy of 0.1°C. The probe was kept in a 40°C water-bath between the

measurements to reduce the time required to make each measurement. The average latency from the start of the capture to reading the temperature was 1.5 min. The temperature was read after it had been stable for more than 15 s. The fox was then weighed in a weighing sack to induce additional acute stress to the animal. After weighing, the fox was returned to its cage. Twenty minutes after the first measurement, the fox was captured again and its rectal temperature was recorded for a second time. Thus, the first temperature measurement and the weighing were expected to act as stressors that would lead to stress-induced hyperthermia (SIH; see Moe 1996). Temperatures were measured between 0930h and 1300h on two subsequent days (24 animals per day). Temperatures were measured in rotation from foxes in each of the four groups.

The foxes were weighed three times (Table 1) with a Mettler PE 12 balance (Mettler Instrument AG, Zürich, Switzerland; accuracy 1 g). In December, the foxes were euthanised by electrocution according to the methods recommended by the Standing Committee of the European Convention (European Convention 1998) and pelted. The carcasses were dissected for measuring the sizes of various organs. The heart and brain were weighed with a Sartorius V6100-*-F7 balance (Sartorius Gmbh, Göttingen, Germany; accuracy 0.1 g) and the adrenal glands with a Mettler AE 163 balance (accuracy 1 mg). The body length was measured to an accuracy of 0.5 cm. Tibia length was measured to an accuracy of 1 mm after removal from the carcass and cleaning.

Statistical analyses

The data were analysed using SPSS statistical software (SPSS Inc, Chicago, IL, USA). The differences between the groups were compared using one-way analysis of variance (Norusis 1990), Mann-Whitney test, or Kruskal-Wallis one-way analysis of variance. Multiple pair-wise comparisons following the Kruskal-Wallis tests were computed, as described by Siegel and Castellan (1988). Comparisons including repeated or dependent measurements were carried out using multivariate analysis of variance (MANOVA), Friedman two-way ANOVA, or Wilcoxon signed ranks test (Norusis 1990). Walk test data were transformed using square-root transformation to meet the assumptions of normal distribution and homogeneity of variances for MANOVA. If the sphericity condition of MANOVA was violated ($P < 0.05$ in Mauchly's test), the degrees of freedom were adjusted using Huynh-Feldt's epsilon. Differences between the groups in the first feeding test were compared with Fisher's exact test. In the Mann-Whitney, Kruskall-Wallis, Wilcoxon and Friedman tests, exact probabilities were calculated or the upper boundary of the 99 per cent confidence interval from the Monte Carlo method with 10 000 samples was used as the *P*-value. Only two-tailed tests were used. *P*-values greater than 0.07 were regarded as non-significant (ns). The results are presented as mean ± standard deviation if not otherwise mentioned.

Results

There were no differences between the four experimental groups in body mass at any time during August, October or December (Table 2), or in body mass gain during the autumn ($F_{4.4,61.7} = 0.80$, $P > 0.07$, MANOVA, group–month interaction). There were no differences between the groups in heart weight, brain weight, adrenal weight, body length or tibia length in December (Table 2). In September, the cortisol:creatinine ratio was lower in group U than in groups O and P, whereas group C did not differ from any other group (Table 2). In October, there were no differences between the groups in the cortisol:creatinine ratio. Taking all of the groups together, the ratio decreased from 3.7 ± 1.3 in September to 2.7 ± 0.6 in October ($P < 0.001$, Wilcoxon, n = 40).

Table 2 **Morphometric and physiological parameters in blue foxes.** *P*: ANOVA (*F* statistic) for body and organ size; Kruskall-Wallis for other measures. Means with different superscripts differ at the level $P < 0.05$ (*post hoc* test; Siegel & Castellan 1988). ns, not significant ($P > 0.07$).

	Group C	Group P	Group U	Group O	*df*	*F*	*P*
Body and organ size	(n = 11)	(n = 11)	(n = 11–12)	(n = 11–12)			
Body weight in Aug (kg)	3.2 ± 0.7	3.1 ± 0.5	3.3 ± 0.7	3.4 ±0.8	3,42	0.279	ns
Body weight in Oct (kg)	8.1 ± 1.3	8.3 ± 0.8	8.4 ± 0.7	8.6 ± 1.3	3,42	0.455	ns
Body weight in Dec (kg)	10.1 ± 1.3	10.3 ± 0.8	10.3 ± 0.9	10.1 ± 1.3	3,42	0.186	ns
Heart weight in Dec (g)	33 ± 3	33 ± 2	33 ± 2	34 ± 3	3,40	0.414	ns
Brain weight in Dec (g)	37 ± 1	37 ± 2	37 ± 2	37 ± 2	3,40	0.033	ns
Body length in Dec (cm)	67 ± 2	67 ± 2	67 ± 2	67 ± 2	3,40	0.208	ns
Tibia length in Dec (cm)	13.8 ± 0.5	13.7 ± 0.4	13.6 ± 0.4	13.8 ± 0.4	3,40	0.770	ns
Adrenal weight (both adrenals) in Dec (g)	0.34 ± 0.04	0.33 ± 0.04	0.34 ± 0.05	0.34 ± 0.04	3,40	0.232	ns
Cortisol:creatinine ratio (nmol l^{-1}:mmol l^{-1})	(n = 11)	(n = 11)	(n = 10–11)	(n = 9–12)			
In September	3.5 ± 1.0^{ab}	4.5 ± 1.9^{b}	2.8 ± 0.6^{a}	3.9 ±0.9^{b}	-	-	< 0.05
In October	2.7 ± 0.7	2.7 ± 0.8	2.6 ± 0.6	2.8 ± 0.5	-	-	ns
Rectal temperature in October (°C)	(n = 10)	(n = 11)	(n = 12)	(n = 12)			
Before handling (T_1)	39.7 ± 0.3	39.8 ± 0.4	39.9 ± 0.3	39.8 ± 0.5	-	-	ns
After handling (T_2)	40.0 ± 0.5	40.2 ± 0.4	40.1 ± 0.3	40.2 ± 0.4	-	-	ns
Difference (T_2–T_1)	0.3 ± 0.3	0.5 ± 0.3	0.2 ± 0.3	0.4 ± 0.4	-	-	ns

In the temperature test, the blue foxes' rectal temperature increased from 39.8 ± 0.4°C before handling to 40.1 ± 0.4°C 20 min after handling ($P < 0.001$, Wilcoxon, n = 45), but there were no differences between the groups in the temperatures before (T_1) or after (T_2) the handling, or in the temperature change (Table 2). The measuring order did not affect T_1, T_2 or $T_2 - T_1$ ($|r_s| < 0.2$ and $P > 0.35$ for all Spearman correlations).

There were no differences between the groups in the proportion of blue foxes eating in the first feeding test, or in the number of tests (out of a total of five) during which the foxes ate (Table 3). The foxes not eating in the first feeding test (n = 21) ate, in total, in 1.4 ± 1.7 tests (both median and mode were zero), whereas the foxes eating in the first test (n = 25) ate in 4.2 ± 0.9 tests (median = 4, mode = 5; $P < 0.001$, Mann-Whitney). This result demonstrates the repeatability of the test. The more frequently a fox ate in the feeding tests, the more often it was observed in the front section of the cage during the walk test ($r_s = 0.38$, $P < 0.01$, n = 46, Spearman).

There were no group differences between the foxes in the time they spent performing the behaviours of locomotion, sitting and resting during the 24 h video-recordings in week 39–40 (September–October) or week 45–46 (November) (Table 3).

As shown in the 24 h video observations, the use of the platforms by blue foxes in groups P, O and U decreased from the September–October recording period to the November recording period (Table 4). At the same time, the use of the front section of the cage increased. There was only a slight increase in the use of the middle and rear sections. However, the increase in use of the front section was more prominent in the groups with the concealment screens in the rear section of the cage (groups U and O) than in the group without screens (group P). Altogether, in both September–October and November, the foxes

Table 3 **General activity and feeding test behaviour in blue foxes.** *P*: ANOVA ($F_{3,42}$ statistic) for general activity; Fisher's exact test for the first feeding test; Kruskall-Wallis for the repeated feeding test. ns, not significant ($P > 0.07$).

		Group C (n = 11)	Group P (n = 11)	Group U (n = 12)	Group O (n = 12)	*F*	*P*
General activity (% of 24 h observations)							
In September–October:							
	Locomotion	17 ± 4	17 ± 8	14 ± 5	13 ± 4	1.75	ns
	Sitting	12 ± 5	10 ± 3	11 ± 3	10 ± 4	0.98	ns
	Resting	71 ± 5	73 ± 8	75 ± 6	77 ± 5	2.03	ns
In November:	Locomotion	15 ± 5	13 ± 4	14 ± 4	18 ± 7	1.83	ns
	Sitting	13 ± 4	18 ± 8	13 ± 5	13 ± 5	1.99	ns
	Resting	72 ± 7	69 ± 8	73 ± 5	69 ± 8	1.22	ns
Feeding test in October							
	% foxes eating in the first test	64	55	50	50	-	ns
	No. tests (out of 5) in which fox ate	2.9 ± 2.1	3.2 ± 1.5	2.4 ±2.1	3.3 ± 2.1	-	ns

Table 4 **The use of the various cage sections (% of observations) by blue foxes in groups P, U and O in the 24 h video-recordings in September–October and November.** The differences between the positions within each month are significant ($P < 0.05$, Friedman) for each group separately and for the groups together. P_1: Difference between groups (Kruskall-Wallis, $df = 2$). P_2: Difference between months (Wilcoxon). ns, not significant ($P > 0.07$).

	Group P (n = 11)	Group U (n = 12)	Group O (n = 12)	All	P_1
September–October					
Front	22 ± 11	21 ± 12	24 ± 16	22 ± 13	ns
Middle	6 ± 4	12 ± 11	5 ± 3	8 ± 8	ns
Rear	14 ± 8	9 ± 6	8 ± 4	10 ± 6	= 0.065
Platform	58 ± 17	58 ± 20	63 ± 17	60 ± 18	ns
November					
Front	28 ± 14	52 ± 15	41 ± 23	41 ± 20	< 0.05
Middle	14 ± 6	16 ± 9	10 ± 10	14 ± 9	ns
Rear	33 ± 17	4 ± 4	12 ± 5	16 ± 16	< 0.001
Platform	24 ± 25	27 ± 20	37 ± 26	30 ± 23	ns
P_2					
Front	= 0.067	< 0.01	< 0.01	< 0.001	
Middle	< 0.01	ns	< 0.05	< 0.001	
Rear	< 0.01	ns	ns	= 0.061	
Platform	< 0.01	< 0.01	< 0.01	< 0.001	

in groups U and O spent less time in the rear section of the cage than did the group P foxes. In the control group (C; n = 11), the use of the various parts of the cage did not change ($P > 0.07$, Wilcoxon) from September–October to November: front section 47 ± 17 versus 42 ± 24 per cent; middle section 21 ± 10 versus 17 ± 13 per cent; rear section 34 ± 15 versus 41 ± 19 per cent. There were differences between the use of the locations in both time

periods: $P < 0.05$ and $P = 0.062$ (Friedman), September–October and November, respectively.

During the walk tests (Figure 2), blue fox groups with platforms (P, n = 11; O, n = 12; and U, n = 12) were observed most frequently on platforms, then in the front section of the cage, and least frequently in the middle section of the cage and under the platform (position: $F_{2.38,76.1} = 36.3$, $P < 0.001$, MANOVA). Blue foxes in group U were observed more frequently under the platform (ie in the rear section) and less frequently on the platform during the walk test than foxes in groups P and O (position–group interaction: $F_{2.38,76.1} = 3.47$, $P < 0.05$ for U versus P + O comparison; $F_{2.38,76.1} = 0.690$, $P > 0.07$ for P versus U comparison). Over the course of the autumn, animals in groups P and O increased their use of the front and middle sections of the cage and decreased their use of the rear section, whereas animals in group U increased their use of the front section but decreased use of the middle section; the decline in the use of the rear section was not so steep in group U as in groups P and O (position–group–period interaction: $F_{4.76,152} = 4.44$, $P < 0.05$ for U versus P + O comparison; $F_{4.76,152} = 0.149$, $P > 0.07$ for P versus U comparison). In all three groups, the platforms were used most frequently in the middle of the autumn (period–position interaction: $F_{4.76,152} = 20.4$, $P < 0.001$). The blue foxes that did not have the possibility of getting onto the platform (group C) tended to stay in the front or middle rather than in the rear section of the cage (position: $F_{2,20} = 17.0$, $P < 0.01$), and this trend was strengthened towards the late autumn (position–period interaction: $F_{4,40} = 14.3$, $P < 0.01$).

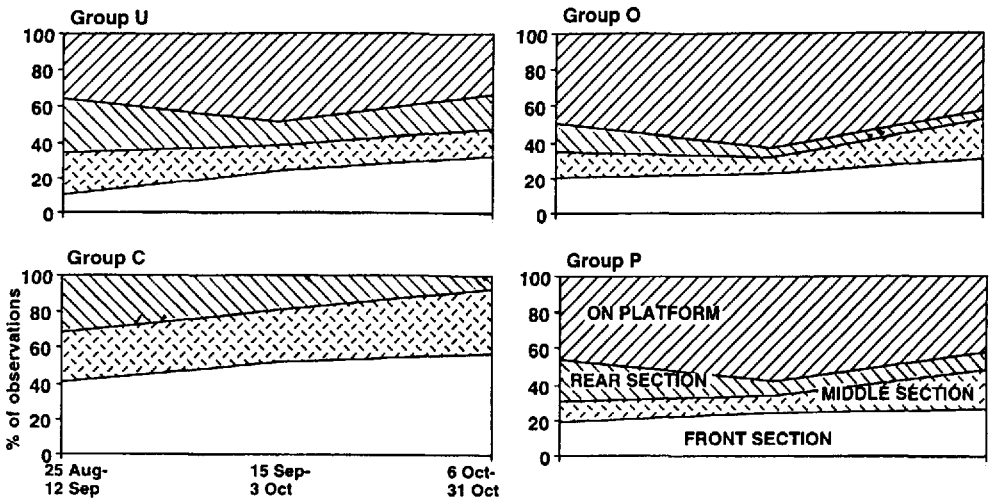

Figure 2 **Blue foxes' position in their cages during the walk tests.** The data are based on 27 observations in each period. See Figure 1 and text for details of the various groups and positions and the results of the statistical tests.

The use of the various cage sections as measured during the walk tests correlated positively with the video-recorded measurements for the platform ($r_s = 0.51$, $P < 0.01$, n = 35, Spearman, groups P, U and O) and for the middle section ($r_s = 0.51$, $P < 0.01$), but not for the front ($r_s = 0.17$, $P > 0.07$) or the rear section ($r_s = -0.12$, $P > 0.07$). Video-recording results from September–October and November were combined when calculating these correlations.

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Discussion

Previous studies have shown that the view from the cage affects the positional choices of farmed blue foxes. They prefer platforms without walls to platforms with walls (Mononen *et al* 1993; Korhonen & Niemelä 1996), and, when given a choice between two cages, they avoid to some extent the cage from which the view is more restricted (Mononen *et al* 1996b, 1999a). The present results from the video-recordings indicate that in studies using just one cage, it is, likewise, the view that affects blue foxes' choices regarding their position preferences on the cage floor: the foxes tended to avoid those floor sections from which the view was obstructed by the concealment screens. Furthermore, in agreement with many earlier studies (eg Korhonen *et al* 1995, 1996; Korhonen & Niemelä 1996), the most popular position was that with the best possible view — the platform. Apparently, blue foxes are keen to see what is happening around them, and Rekilä *et al* (1996) have shown that the environment outside the cage strongly affects the behaviour of the foxes. Foxes in cages nearest to the everyday movements of farm staff and visitors were the most active in their home cages and also in an open-field test, and they were the least fearful in a feeding test.

Twenty-four-hour recordings of foxes may not, however, reveal the foxes' possible need for a hiding place in more acute situations. We therefore conducted the walk tests, which resembled an everyday farm situation — a human approaching the animals via the corridor of the shed. Although there was some correlation between the behaviour of foxes during the 24 h recordings and in the walk tests, there were also some marked differences in the results. These differences are partly attributable to the fact that the walk tests were carried out during the work-day (ie the most active phase of the day), whereas the video results also included the evening and night, when foxes spend more of their time resting (see eg Rekilä *et al* 1996 for the activity phases of farmed blue foxes). There was, however, one particularly interesting difference. In the walk tests, the blue foxes that had the possibility of moving behind the concealment screen (group U) were observed slightly more often in that section of the cage than foxes in cages where the section offered no cover from the approaching man (groups P and O), although, during the 24 h observations, the section behind the screen was used less by groups U and O than by group P. Thus, it can be concluded that the space behind the screen was used to some extent for hiding from an approaching man in group U.

Blue foxes' escape behaviour has also been demonstrated by Pedersen and Jeppesen (1993). They used a cage system comprising a double cage, with a platform and three nest boxes in one of the cages. During tests rather similar to our walk test, 25–30 per cent of their adult blue foxes were observed in the nest boxes, but this percentage was doubled when the foxes were intentionally disturbed by a man making sudden movements towards the cage and hitting the cage with a stick.

The blue fox is a colour mutation of the arctic fox, which lives in arctic areas with open landscape (Nowak & Paradiso 1983) and may prefer elevated den sites (Underwood & Mosher 1982). When threatened, arctic foxes escape to dens (Frafjord *et al* 1989), which may be their only opportunity to protect themselves against attacks from larger and faster predators (Mononen 1996). Accordingly, the observed general preference of farmed blue foxes for open views and elevated positions, and for hiding places in acutely threatening circumstances, may reflect the behaviour of the species in its natural habitat. Because platforms and hiding places enable the foxes to perform these 'natural' behavioural patterns, they could be regarded as biologically relevant improvements to the cage environment.

Only a few studies have used methods other than preference testing to assess the effects of cage furnishing on the welfare of blue foxes. Jeppesen and Pedersen (1990) compared blood

cortisol, eosinophil leucocytes and fearfulness levels of blue foxes in barren cages with those of foxes in cages with one platform and three nest boxes, but failed to discover any clear differences between the groups after a two-year experiment. Harri *et al* (1995) found that blue foxes with elevated platforms or nest boxes were more active at the beginning of an open-field test, and less fearful when captured, than blue foxes without any furnishing in their cages. Rekilä *et al* (1996) did not find any differences in open-field behaviour, capture-test behaviour or feeding-test behaviour between blue foxes with nest boxes, platforms or no furnishing in their cages, but the total daily activity in the home cage was lower in foxes living in unfurnished cages. The results of studies by Harri *et al* (1995) and Rekilä *et al* (1996) indicate that cage furnishing affects the behaviour of blue foxes, and they suggest that foxes with cage furnishing are more able to perform active coping behaviours than animals in barren cages. However, as discussed by Rekilä (1999), most behavioural tests used for foxes have not been properly validated, and their relation to the welfare of the animals is unclear.

Moe (1996) has shown that stressful situations cause hyperthermia in farmed silver foxes. We observed stress-induced hyperthermia (SIH) in blue foxes also. It can be hypothesised that the increase in body temperature during acutely stressing circumstances should be more pronounced in more stress-sensitive animals. In fact, detailed analyses of the present blue fox data (presented in Mononen *et al* 1999b) indicate that SIH correlates positively with adrenal mass, fearfulness (the tendency not to eat in the feeding test) and restlessness (the tendency to move about instead of resting). However, the present study shows that individual variation in SIH, adrenal mass, behaviour in the feeding test or daily activity was not associated with the variation in the cage history of the animals.

In contrast to other stress indicators, there was a difference in the urinary cortisol:creatinine ratio between the experimental groups: the blue foxes with the opportunity to hide behind the screen under the platform (group U) had lower values than the foxes with platforms but without the opportunity to hide (groups P and O). However, the difference was observed only in September, and not one month later. Furthermore, the animals in the control group did not differ significantly from those in any other group, although these animals had the most barren environment. Thus, it is tempting to regard the cortisol:creatinine ratio results as incidental, although they could be explained as follows.

It has been documented that there are marked inter-individual differences in the fearfulness of blue foxes (Rekilä 1999). These differences have a genetic basis, and the fearful foxes — those not eating in the feeding test — have higher urinary cortisol:creatinine ratio than those foxes that do eat in the test. However, fearfulness also depends on the ontogeny of the animals. Dalsgaard and Pedersen (1999) have shown that female blue foxes that have been exposed to extra human contact in the form of handling at 7–10 weeks of age were less fearful later and reproduced more reliably than foxes that had been subjected only to normal farm routines at a young age. In the present study, human disturbance was intensive during the mounting of the collector funnels for urine sampling. This disturbance may have increased adrenal cortex activity, particularly in fearful blue foxes. The hiding opportunity may have helped fearful individuals in group U to cope better than the fearful individuals in groups P and O when confronted with this fear-evoking situation. It has been reported that many blue foxes escape onto platforms when disturbed (Korhonen & Niemelä 1996), even though being on the platform provides them with no concealment. Foxes in our control group (C), with no platform onto which to withdraw, may to some extent have learned by the time of the first urine collection that the presence of man is not a real threat. Thus, the provision of the platform onto which the fox could withdraw but the absence of a screen enabling the fox to hide from approaching man (groups P and O) may have resulted in

the fearful animals remaining fearful longer than their counterparts without a platform (group C). Control foxes were observed in the front section of the cage more frequently than foxes with platforms. Furthermore, the foxes that seldom ate in the five feeding tests were observed in the front section less often than those foxes that ate more frequently in the test.

The failure to detect any differences in the urinary cortisol:creatinine ratio in October may be attributable to most animals having already been habituated by that time to the presence of man during the urine collection procedure. Indeed, the ratio decreased from September to October, although the opposite trend would be predicted from the yearly fluctuation of the base level of plasma cortisol in blue foxes (Rekilä *et al* 1997b). The habituation to man's presence was also reflected in their behaviour during the walk test, with the foxes from all groups being observed increasingly frequently near the observer during the course of the autumn.

Accordingly, if the above theory is true, it seems that the concealment screens of group U foxes would have alleviated stress, but only in acute situations and only in the early autumn. The later lack of differences between the groups in terms of their stress sensitivity might indicate that the screens did not have any long-term stress-protective effects.

Harri *et al* (1998) found that blue fox cubs that were provided with a nest box for the entire duration of the autumn were more fearful than those cubs without a box. The concealment screens in the present study did not seem to have this negative side effect. Nest boxes may isolate foxes almost completely from man, whereas the concealment screen allows fearful foxes to respond adaptively to man's presence.

Reduced growth can be a sign of stress and poor welfare (Broom & Johnson 1993). Korhonen and Niemelä (1995) did not find any effect of elevated platforms on the growth of blue foxes. Similarly, cage furnishing had no effect on the growth of foxes in the present study. As only minor differences in physiological stress responses were observed between the four blue fox groups, it is no major surprise that there were no differences in the growth of the foxes as measured by body and organ size.

Animal welfare implications

A concealment screen inside the cage may have the dual benefit of increasing blue foxes' control of the situation when confronted by an approaching man and yet enabling the animals to habituate to man. In this respect, it may represent an improvement over a more enclosed hiding place such as a nest box. Thus, the screen may improve the welfare of some blue foxes by alleviating stress, at least in certain acute situations. Despite the strong preference of the blue foxes for using the platforms, no significant differences in indices of welfare were observed between the animals that had access to platforms and those that did not.

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