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EFFECT OF CAGE DIMENSIONS ON WELFARE AND PRODUCTION OF FARMED BLUE FOX

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Abstract

The aim of this study was to assess the impact of high cages on the welfare and production of farmed blue foxes. The experimental groups were housed, two foxes per cage, in three different cage set-ups: 1) standard cage (107 cm long × 115 cm wide × 70 cm high; control group); 2) high cage, walls heightened up to the roof of the shed (107 cm long × 115 cm wide × 140 cm high); 3) wide cage, built to fit between the supporting structures of the shed (107 cm long × 235 cm wide × 70 cm high). Body weight developed normally in all groups. Before pelting, the foxes in the high and the wide cages weighed ca. 0.3 kg more than those in the standard cages. All groups were fed equally large portions, and the foxes usually ate the entire portion. In the capture test, the foxes in the standard cages were usually caught ca. 3 seconds faster than those in the high cages. It took longest to catch foxes in the wide cages. The larger the foxes grew, the longer they took to catch. At pelting, the capture time was longest in the high cages and shortest in the standard cages. The foxes were mainly calm and confident when caught, particularly those in the high cages. They remained healthy throughout the study, and the results of the small blood picture indicated good general health in all groups. The right and left adrenal glands were heaviest in the foxes in the high cages. The roofs of the cages could be raised without difficulty. The door is traditionally on the cage roof but in our study it had to be moved to the front wall of the cage. More work has to be done on the door. When the foxes grew, a second person had to hold the door while they were being caught, which prolonged the catching time. The two doors in the wide cages were located at either end of the cage. This set-up complicated capture, which would be easier if there were only one door in the middle of the cage. In conclusion, it is possible to house blue foxes in cages with the roof raised up to the housing shed roof without any major problems for production. The high cage permits the introduction of new technical solutions to improve foxes' welfare.

Key words: *Alopex lagopus*, enlarged cage, production result, housing conditions

The welfare of farmed animals depends largely on the quantity and quality components of housing space (Wiegand et al., 1994; Korhonen et al., 2001 a, b). In farmed foxes, the quality aspect of housing has been studied intensively in recent years. Today, the obligatory enrichments in cages are a year-round wire-mesh platform and a chewing block made of wood (Korhonen et al., 1996, 2002, 2003; Mononen, 1996). Additional enrichments suggested, but yet not approved, are a concrete floor, a sandbox and a year-round nest box (Hovland and Bakken, 2000; Korhonen et al., 2006; Koistinen et al., 2009). The quantity component of the housing space is related to the amount of space provided. Previous studies have concentrated on establishing the effect of an increase in cage floor area on productivity and welfare (Ahola, 2002). To date, however, findings of the benefit of a larger floor area are scant.

The enhanced well-being of a farmed animal typically increases its productivity. All possible means to improve the comfort and welfare of such animals should therefore be investigated and exploited (Koistinen and Mononen, 2004; Koistinen and Korhonen, 2007). New regulations on larger cages for farmed foxes will come into effect in the near future (Miettinen and Rintamäki, 2007). The dimensions of the standard cage (105 cm × 110 cm × 60 cm), with two juveniles per cage, are to be altered to meet the new criterion (107 cm × 113 cm × 70 cm), which has put pressure on efforts to find ways of enlarging the housing space. The vertical dimensions of the cage are one aspect that has as yet received little attention. The current maximum height of the cage is 60 cm, which is low considering the maximum height of a fox, 35–45 cm, and allows only very restricted vertical movements. One potential enhancement could be to raise the roof of the cage, bringing it closer to the roof of the housing shed and thus doubling the height of the cage. The maximum benefit could then be gained from the vertical space. The fox would have more room to move up and down, which would give it more options for activity and thus possibly improve its welfare.

Blue fox studies have paid more attention to increasing horizontal space, i.e. providing a larger floor area. However, the majority of comparisons have been made either between standard (105 cm long × 120 cm wide) and small (105 cm long × 50 cm wide) cages or between standard and very large pens (500 cm long × 300 cm wide; Korhonen et al., 2001 a). In the conventional shed, two standard cages between supporting structures are typically separated from each other by an empty space. The width of both cages separately is about 115 cm. However, if the empty space with the extra wall were removed, the width could be increased to 235 cm. This solution would be technically easy to implement and yet has not been studied despite its potential for increasing the housing floor area.

Our aim here was to assess the impact of cage dimensions on the welfare and production of the farmed blue fox (*Alopex lagopus*) in the growing season. The dimensional changes studied were: (1) height, i.e. the effect of raising the cage roof to twice the standard height; (2) width, i.e. the effect of doubling the width of the standard cage.

Material and methods

Subjects and experimental groups

The study was carried out at the Fur Farming Research Station of MTT Agrifood Research Finland, in western Finland (63.54°N, 23.54°E). The study lasted from mid-July to the end of November and comprised three experimental groups. The control group consisted of blue foxes raised in ten standard cages (107 cm × 115 cm × 70 cm, L × W × H). The second group consisted of blue foxes raised in ten extra-high cages (107 cm × 115 cm × 140 cm, L × W × H) and the third group comprised blue foxes raised in ten extra-wide cages (107 cm × 235 cm × 70 cm, L × W × H). The experimental groups were formed when the foxes were weaned. Three cubs from the same litter were distributed between the three groups, one male and one female per cage. Altogether, there were 20 blue foxes per experimental group. Once or twice a day the animals were fed a fresh fox feed made by the local feed kitchen (Kannus Minkinrehu Ltd).

Behavioural analyses

Capture test

The animals were weighed four times during the experiment: at weaning on 15 July, and on 3 September, 1 October and 26 November. At the same time the capture test was conducted and the behavioural response to capture was evaluated. The foxes were caught with neck tongs. Capture time was measured from the moment the cage door was opened until the moment the fox had been caught. The response to capture was classified as confident or fearful (Korhonen et al., 2001 a).

Walking test

The reactions of the foxes to humans were evaluated by a walking test (Korhonen et al., 2001 a). The test was conducted three times during the study: on 27–31 August, 10–14 September and 5–9 November. It was performed twice a day, at 7 am and 1 pm, on five consecutive days. In the test an assistant walked slowly past the cages and wrote down the behavioural reactions of the foxes.

Feeding test

A feeding test was conducted to measure how confident or fearful the foxes were in the presence of humans. The assistant gave the fox a portion of feed and then stood in front of the cage, timing how long it took the fox to come and eat. If it did not come within 30 seconds, it was classified as fearful, and the test was aborted (Korhonen et al., 2001 a).

Ball test

Frequent explorative behaviour of a novel object indicates good welfare of an animal (Mononen, 1998; Rouvinen et al., 1999). The explorative behaviour of the blue foxes in this experiment was evaluated by a ball test in which a basketball was placed in the cage. An assistant measured the time it took for a fox to touch the ball. If there was no contact within 30 seconds, the test was aborted.

Behaviour from video recordings

The behaviour of the foxes in the six experimental cages in each group was video recorded three times during the experiment (on 6–7 August, 24–25 September and 29–30 October). The recording equipment comprised twelve black-and-white surveillance cameras, three time-lapse video recorders (Hitachi) and three quads (GS-MS Quad Display). At night, the cages were lit with red lamps (25 W). The behaviour of the foxes was analysed from the tapes using instantaneous sampling at five-minute intervals (Jauhiainen and Korhonen, 2005).

Urine and blood samples

Collector trays for urine samples were fastened under the cages. The samples were collected on 8–9 October, bottled and sent to the University of Kuopio for analysis of cortisol and creatinine (Lasley and Kirkpatrick, 1991). Since the creatinine value describes the concentration level of the urine, the results are presented as cortisol:creatinine ratios.

Blood samples from the foxes were taken on 27 November and sent to the clinical laboratory of MTT at Ypäjä. These samples were used to determine the haemoglobin (Hb) content, haematocrit (HCT) ratio, red blood cell count (RBC) and white blood cell count (WBC).

Organ weights and fur evaluation

Pelting took place on 27 November. The pelts were sent to Finnish Fur Sales in Vantaa for measurement of length and weight, and for evaluation of colour, mass, coverage and quality. The carcasses were prepared and the adrenal glands, liver, spleen and heart were weighed.

Statistical analysis

Statistical analyses were made with the SAS system for Windows 9.1 and SAS Enterprise Guide 3.0 software. All variables that were normally distributed and the validity of the homogeneity of variances were analysed by the Mixed models procedure. Pair-wise comparisons between experimental groups were made with Tukey's test. The data from the walking test and video recordings were not normally distributed. The Kruskal-Wallis test was therefore used to analyse the results, and a pair-wise comparison was made according to Siegel and Castellani (1988). Since there were two foxes in a cage, behaviour was recorded as the mean of events in a cage. The Fisher test was used to analyse the results of the food and ball tests and the capture reactions.

Results

Weight development and feeding

At the beginning of the study, the mean weight of the foxes was the same in all groups. Weight developed normally in all groups during the study (Table 1). At pelting time, the foxes in the high and the wide cages tended to weigh slightly more than those in the standard cages, but the difference was not statistically significant. All groups were fed equally large portions of fox feed. All foxes had a good appetite and normally ate the whole portion. The mean weight of the feed portion was 750 g/animal during July and August, 850 g/animal between August and October and around 1000 g between October and November.

Table 1. Body weights, cortisol:creatinine ratio, the time it took for an assistant to capture the fox (mean ± SD) and fox's reaction to capture. Capture reaction: 1.0 means confident and the closer to 2.0 the value is, the more fearful the fox is. There were no statistical differences between groups in studied variables

Parameter	Date	Cage size		
		standard	high	wide
Body weight (kg)	16th of July	2.8±0.1	2.8±0.1	2.8±0.1
	3rd of Sept	8.0±0.2	8.2±0.2	8.2±0.2
	1st of Oct	10.8±0.2	11.0±0.2	10.9±0.2
	26th of Nov	14.9±0.4	15.2±0.5	15.2±0.4
Cortisol:creatinine	9th of Oct	5.4±0.5	6.7±1.5	7.8±1.9
Capture time (sec)	3rd of Sept	7.1±0.4	10.2±0.4	11.7±1.3
	1st of Oct	7.0±0.4	13.1±0.5	11.0±0.8
	26th of Nov	11.2±1.0	16.4±0.7	13.0±1.5
Reaction to capture	3rd of Sept	1.2	1.2	1.6
	1st of Oct	1.0	1.4	1.8
	26th of Nov	1.0	1.0	1.0

Capture reactions

On average, foxes were caught three seconds more quickly in the standard than in the high cages the first time that capture time was measured (Table 1). Capture took longest in the wide cages. The time needed for capture increased in all groups as the foxes grew. At pelting, the capture time was shortest in the standard cages and longest in the high cages. When caught, the foxes were mostly calm and confident. In September and October, the most confident foxes were those in the standard and the high cages. In November, the foxes in all groups responded confidently to capture (Table 1).

Stress hormones and blood picture

There was no statistical difference in the cortisol:creatinine ratio between the groups (Table 1), although the mean value was highest in the foxes in the wide cages and lowest in those in the standard cages.

The animals remained healthy throughout the study, and the blood picture parameter showed that general health was good in all groups (Table 2). There was no statistical difference in haemoglobin, haematocrit, red blood cell or white blood cell values between the groups, and all the values were within the normal rage (Korhonen et al., 2001 a, b).

Organ weights

Only the weight of the adrenal gland differed significantly between the groups ($P<0.01$). Both the right and the left adrenal glands were lightest in the foxes in the high cages. The foxes in the wide cages had the heaviest adrenal glands. There was no statistically significant difference in the weight of other organs (Table 2).

Table 2. Mean weights (mean ± SD) of organs and mean values (mean ± SD) of small blood count. Means with the different uppercase letters are significantly different, P<0.01

Organs	Cage size		
	standard	high	wide
Adrenal gland, right (mg)	269 ± 29 a	201 ± 23 b	295 ± 17 a
Adrenal gland, left (mg)	282 ± 23 a	239 ± 19 b	382 ± 23 c
Heart (g)	58.4 ± 2.0	58.3 ± 2.9	62.7 ± 2.1
Spleen (g)	13.3 ± 1.0	14.7 ± 1.3	12.6 ± 0.9
Liver (g)	467 ± 27	413 ± 17	502 ± 38
Small blood count			
haemoglobin (g/l)	160 ± 2.0	160 ± 3.7	162 ± 2.6
haematocrit (%)	51.7 ± 0.7	51.4 ± 1.3	51.8 ± 0.9
red blood cells (10^9 cells 1^{-1})	8.9 ± 0.8	8.0 ± 0.6	7.7 ± 0.6
white blood cells (10^9 cells 1^{-1})	8.8 ± 0.1	8.7 ± 0.2	8.7 ± 0.2

Fur properties

The results of fur evaluation are shown in Table 3. There was no statistically significant difference between the groups in the quality of fur or other variables measured. Thus, pelts of equal quality can be produced in all the cage set-ups compared in this study.

Table 3. Fur properties in experimental groups (mean ± SD). There were no significant differences in studied variables

Parameters of fur condition	Cage size		
	standard	high	wide
Length (cm)	123.8 ± 1.1	123.5 ± 1.5	123.9 ± 1.4
Weight (g)	802 ± 17.5	818 ± 21.5	828 ± 23.5
Colour	6.1 ± 0.2	6.3 ± 0.2	6.2 ± 0.2
Purity of colour	9.2 ± 0.3	9.1 ± 0.2	9.2 ± 0.3
Mass	7.0 ± 0.4	7.3 ± 0.4	7.2 ± 0.4
Coverage	8.2 ± 0.3	8.3 ± 0.2	8.3 ± 0.2
Quality	6.7 ± 0.4	7.0 ± 0.4	6.9 ± 0.4

Behaviour

The foxes living in high cages were the most confident in the presence of humans ($P<0.05$) (Fig. 1). In September, there was no statistical difference between the groups in the frequency of explorative behaviour towards a novel object (Fig. 2). In October, fewer animals were explorative in high than in standard cages ($P<0.05$).

Behaviour as analysed from the video recordings is presented in Table 4. The behaviour of the foxes did not differ markedly between the groups. The foxes rested in the cages for most of the day. Resting was most frequent in August in all groups and decreased towards the end of October. The foxes in the wide cages rested on cage bottom the most in October. Resting on platform, on the other hand, was lowest in the wide cage. Only a few cases of stereotypical behaviour were observed in any group and no significant difference was found between the groups. The foxes in the standard cages had the most social contacts. A few cases of vertical movement were observed, least frequent in the wide cages.

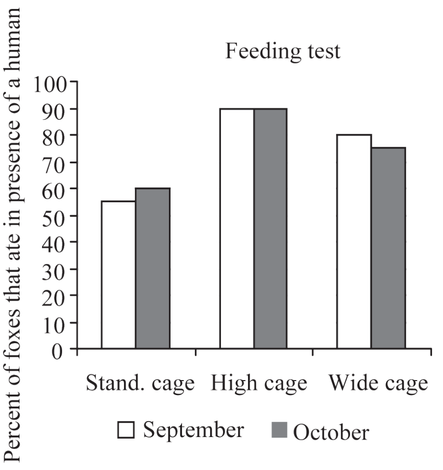

Figure 1. The percent of foxes that ate in presence of a human. High cage differed significantly ($P<0.05$) from standard cage in each month

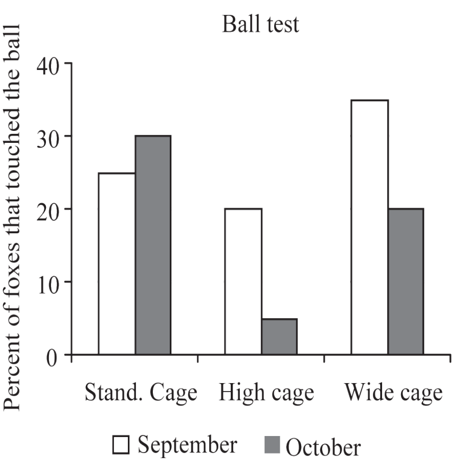

Figure 2. The percent of foxes that touched the ball in the ball test. There were no significant differences between the groups in September. In October, fewer animals were explorative in high than standard cage ($P<0.05$)

The behavioural responses in the walking test are given in Table 5. Resting was most common in the high cages. The foxes in wide cages ran around significantly more than did those in other cage set-ups, whereas the foxes in the high cages seemed to be calmer. Only a little vertical movement was observed and there was no statistical difference between the groups. Scratching the feeding plate was pronounced in September in the high cages.

Table 4. Video recorded behaviour in different cage set-ups. Behaviour is observed using instantaneous sampling method with five-minute interval

Behaviour	Standard cage	High cage	Wide cage	P
1	2	3	4	5
Sit				
August	3.9 ± 3.0	6.4 ± 4.5	3.5 ± 2.3	NS
September	9.4 ± 4.2	11.2 ± 4.9	13.2 ± 5.1	NS
October	15.4 ± 5.3	12.7 ± 4.7	15.6 ± 6.9	NS
Stand				
August	1.4 ± 0.9	1.8 ± 1.3	1.6 ± 1.2	NS
September	4.1 ± 2.7	3.6 ± 2.4	3.6 ± 2.2	NS
October	5.1 ± 2.9	4.9 ± 3.5	5.1 ± 3.4	NS
Rest on the bottom of the cage				
August	80.6 ± 15.0	65.8 ± 19.3	74.6 ± 20.5	NS
September	45.6 ± 28.1	51.5 ± 20.1	59.8 ± 19.6	NS
October	45.4 ± 26.4	43.8 ± 26.0	63.4 ± 18.2	<0.05
Rest on the platform				
August	6.2 ± 12.4	17.9 ± 21.1	15.0 ± 19.9	NS
September	32.9 ± 29.6	21.7 ± 19.1	14.8 ± 18.6	<0.05
October	23.1 ± 25.4	29.1 ± 24.7	8.1 ± 13.5	<0.05
Activity on the platform				
August	0.1 ± 0.3	2.8 ± 2.2	1.2 ± 1.5	<0.01
September	0.8 ± 1.5	3.7 ± 3.0	1.0 ± 1.7	<0.05
October	2.1 ± 1.7	5.2 ± 4.6	0.4 ± 1.0	<0.01
Jump onto/from platform				
August	0.1 ± 0.2	0.0 ± 0.0	0.0 ± 0.0	NS
September	0.0 ± 0..0	0.2 ± 0.5	0.1 ± 0.2	NS
October	0.0 ± 0.0	0.0 ± 0.0	0.1 ± 0.5	NS
Vertical movement				
August	0.0 ± 0.0	0.1 ± 0.3	0.0 ± 0.0	NS
September	0.1 ± 0.3	0.1 ± 0.3	0.0 ± 0.0	NS
October	0.2 ± 0.4	0.3 ± 1.0	0.1 ± 0.3	NS
Contact with wooden block				
August	0.6 ± 0.7	0.5 ± 0.6	0.4 ± 0.6	NS
September	1.7 ± 1.6	1.7 ± 1.8	1.5 ± 1.3	NS
October	0.8 ± 1.1	0.3 ± 0.5	1.7 ± 2.4	NS
Walking in the cage				
August	1.1 ± 1.1	1.6 ± 1.6	1.3 ± 1.0	NS
September	2.1 ± 1.8	2.0 ± 1.1	1.9 ± 1.8	NS
October	2.8 ± 2.6	1.4 ± 1.5	3.6 ± 2.5	NS
Stereotypy				
August	2.0 ± 2.2	1.1 ± 0.8	1.0 ± 1.0	NS
September	1.7 ± 2.0	3.3 ± 2.5	2.8 ± 1.3	NS
October	2.0 ± 1.6	0.7 ± 1.1	0.6 ± 1.1	NS

Table 4 – contd.

1	2	3	4	5
Social contact				
August	2.9±2.1	0.7±1.3	0.9±0.5	<0.05
September	1.7±1.5	1.0±1.5	0.8±0.6	NS
October	1.6±1.1	0.7±0.9	1.0±1.1	NS
Jumping				
August	0.0±0.0	0.0±0.0	0.0±0.0	NS
September	0.0±0.0	0.0±0.0	0.0±0.0	NS
October	0.1±0.3	0.0±0.0	0.0±0.0	NS
Biting itself				
August	1.1±0.8	1.3±1.5	0.5±0.8	NS
September	0.1±0.2	0.0±0.0	0.5±0.7	NS
October	1.3±1.5	1.0±1.1	0.3±0.6	NS

Table 5. Behavioural responses of blue foxes in different cage set-ups evaluated using a walking test (mean±SD). Means with the different uppercase letters are significantly different

Behaviour	Standard cage	High cage	Wide cage	P
1	2	3	4	5
On platform				
August	32.0±12.3	23.5±9.1	27,0±18.4	NS
September	30.5±17.2	29.0±10.5	29.0±17.9	NS
November	15.0±10.5 a	35.0±9.7 b	24.0±13.9 ab	<0.01
Sits				
August	7.5±5.9	13.0±9.2	10.5±7.3	NS
September	15.5±8.3	19.5±10.7	13.0±4.2	NS
November	22.5±15.9	24.5±13.4	25.5±14.0	NS
Stands				
August	27.5±15.7	25.0±12.7	26.5±16.2	NS
September	29.5±18.6	24.5±13.8	29.0±9.1	NS
November	38.5±12.5	24.0±17.5	25.0±9.4	NS
Rests				
August	17.0±8.9 ab	29.5±16.6 a	12.0±8.6 b	<0.05
September	9.0±8.1a	18.5±5.3 b	14.5±7.3 ab	<0.05
November	9.5±6.0	11.0±11.5	12.0±6.8	NS
Approaches				
August	15.5±9.6	7.5±9.8	9.5±12.1	NS
September	12.5±6.8	5.0±6.2	8.5±8.2	NS
November	10.5±7.3 a	3.5±4.1 b	2.5±3.5 ab	<0.05
Retreats				
August	0.0±0.0	0.0±0.0	2.0±2.6	<0.05
September	0.0±0.0	0.0±0.0	0.0±0.0	NS
November	0.5±1.6	0.5±1.6	0.5±1.6	NS

Table 5 – contd.

1	2	3	4	5
Jumps on the platform				
August	0.0±0.0	0.0±0.0	0.0±0.0	NS
September	0.0±0.0	0.0±0.0	0.0±0.0	NS
November	0.0±0.0	0.0±0.0	1.0±2.1	NS
Vertical movement				
August	0.0±0.0	0.0±0.0	0.0±0.0	NS
September	1.0±3.1	1.0±2.0	0.5±1.6	NS
November	0.0±0.0	0.0±0.0	0.0±0.0	NS
Runs				
August	0.5±1.6 a	1.0±2.1 a	12.5±10.1 b	<0.001
September	1.0±2.11 ab	0.0±0.0 a	4.5±3.7 b	<0.01
November	3.5±4.74	1.5±2.4	9.5±11.2	<0.05
Scratches the feeding plate				
August	0.0±0.0	0.0±0.0	0.0±0.0	NS
September	1.0±2.1	3.5±3.4	0.0±0.0	<0.01
November	0.0±0.0	0.0±0.0	0.0±0.0	NS
Eats				
August	0.0±0.0	0.1±0.6	0.0±0.0	NS
September	0.0 ± 0.0	0.0 ± 0.0	0.1 ± 0.2	NS
November	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	NS

Discussion

Comprehensive scientific interest has been to improve the housing environment of farmed foxes by both enriching the traditional cage and increasing its size (Mononen, 1996; Hovland and Bakken, 2000; Ahola, 2002; Koistinen et al., 2009). The results have shown that cage size per se has no or minimal essential value for animal welfare. It is, however, important that the housing cage should enable foxes to engage in behaviours such as escape, hiding, rest, watching the surroundings, play, gnawing, etc. These can be passably satisfied by offering the foxes platform and wooden block, both of which are now obligatory on farms (Korhonen et al., 2001 a, 2002). Our present study, in which the height of the cage was increased substantially, provides yet a further dimension to enrichment of the cage environment. The animal would have here more space to vertical behaviour if necessary.

The optimal quantity and quality of housing space is highly dependent on animal species and their behaviour repertoire. Animals do not necessarily have specific requirement for a certain area or space; more important are the behavioural and physiological needs that the space in question can satisfy (Stricklin, 1995; Ahola, 2002). In our study, we expected the higher and wide cage to permit a greater repertoire of behaviour than the traditional cage. However, no dramatic differences in behaviour between cage dimensions were found. There was little vertical behaviour in any of the groups, though, as expected, such behaviour appeared to be most frequent in the set-up with the higher cage.

It took longer to catch foxes in high and wide cages than in traditional-sized cages. This is understandable, since it is typically more complicated to catch an animal in a larger than a smaller area (Korhonen et al., 2001 a). The extent to which this may be a problem for the farmer is difficult to estimate. However, the difference in capture time between conventional and larger cages did not exceed 5 seconds per animal. The increase in capture time is thus not very dramatic.

The door of the housing cage is usually on the roof, but in our set-up it had been moved to the wall. When the foxes were larger, a second person had to hold the door open while they were being caught, which prolonged the time spent on the catching operation. Clearly, we have to look more closely into the door type. The wide cage had two doors, which were located at either end of the cage. The use of two end doors had advantages but it also complicated capture to some extent. Capture would probably be easier if there were only one door located in the middle of the wide cage. This set-up needs further study before a final conclusion can be drawn.

The platform is obligatory in the cages of farmed foxes today. It enables the animals to rest and to observe their surroundings (Korhonen et al., 1996; Mononen, 1996; Hovland and Bakken, 2000). The platform is typically about 25 cm from the roof of the cage, giving the fox only rather limited space above it. Thus adult foxes can only lie on the platform, and have no room to either sit or stand. Furthermore, the limited space above the platform easily causes the neck hair to wear and so reduces the value of the fur. The high cage tested here provides additional elements in that the foxes have free vertical space above the platform where they can sit or stand. This allows additional vertical movements if necessary.

Our behavioural tests revealed some differences between the groups. In the feeding test, the foxes were most confident, i.e. less fearful towards humans, in the high cage. This is an important finding, as fearfulness is considered a crucial trait when developing the character of farmed animals (Harri et al., 1995). Thus, the high cage appears to promote the confidence of animals. In contrast, the ball test, which measures the explorativeness of animals (Rouvinen et al., 1999), did not show parallel result. Thus, larger vertical space does not promote development of explorativeness to novel object.

The two most common indicators of stress in farmed foxes are adrenal size and cortisol:creatinine ratio (Hovland and Bakken, 2000; Korhonen et al., 2001 b). We analysed both of these variables in our study. The adrenals turned out to be smallest in the high-cage animals. The results were the same for both the left and the right adrenal glands. The general principle is that long-term stress may enlarge the adrenal glands. Our findings led us to assume that the amount of stress experienced may have been lowest in the animals in the high cage. Confirmation of this conclusion is provided by the feeding test, which revealed that the foxes in the high cage were less fearful. However, cortisol:creatinine analyses did not reveal any statistical differences between the groups. Previous studies have shown that the results of stress hormone analyses are not necessarily the same as those of organ size analyses

(Korhonen et al., 2001 b). This complicates the conclusion. A third indicator of prolonged stress is typically the frequency of stereotypies (Hovland and Bakken, 2000). Our results showed that the occurrence of stereotypies was low in general, and that there were no significant differences between the groups.

A larger area, although not necessarily important for the animal per se, permits better possibility to increase enrichment than a smaller area. Furthermore, a larger area permits the animal to choose its place in the space and also to escape, thus giving it better control over its own behaviour (Pedersen and Jeppesen, 1998; Ahola, 2002). Enrichments are recognized as crucial for the wellbeing of farmed animals today (Hovland and Bakken, 2000; Ahola, 2002). Cages of their present size permit the addition of enrichments such as platforms and chewing objects. They also enable the provision of nestboxes for whelping vixens. The year-round use of nestboxes is difficult to arrange in conventional cages. Our high cage leaves enough space for the introduction of new technical solutions to improve foxes' welfare, such as the installation of two platforms instead of only one. It further permits the use of different kinds of nestboxes for periodical and year-round use.

Our results do not show any marked differences in production parameters such as growth and fur properties between cage sizes. All animals grew well and produced good quality fur coats. Furthermore, the blood picture indicated good general health in all experimental groups. The frequency of stereotypies was also low, showing that the foxes had no difficulty in adapting to the housing set-ups tested. Thus, in principle, all three cage set-ups are suitable for animal production.

Conclusions

The animals grew well, remained healthy and produced good fur in all the experimental set-ups. Of the three options studied, the high cage seemed to be the least stressing. Further, because of the high roof, the foxes in a high cage are able to sit on the platform without the roof wearing down the fur on their backs. The extra height also makes it possible to attach another platform to the wall. Our conclusion is that the high cage is at least as suitable for housing foxes as is the traditional standard cage.

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Wpływ wymiarów klatki na dobrostan i produkcję fermowych lisów niebieskich

STRESZCZENIE

Celem badania była ocena wpływu wysokich klatek na dobrostan i produkcję fermowych lisów niebieskich. Grupy doświadczalne (dwa lisy na klatkę) utrzymywano w trzech różnych rodzajach klatek: 1) klatka standardowa (dł. 107 cm × szer. 115 cm × wys. 70 cm; grupa kontrolna); 2) klatka wysoka, o ścianach sięgających dachu pawilonu (dł. 107 cm × szer. 115 cm × wys. 140 cm); 3) klatka szeroka, sięgająca ścian nośnych pawilonu (dł. 107 cm × szer. 235 cm × wys. 70 cm). Rozwój masy ciała przebiegał normalnie we wszystkich grupach. Przed skórowaniem lisy w klatkach wysokiej i szerokiej ważyły około 0,3 kg więcej niż zwierzęta w klatkach standardowych. Wszystkie grupy żywiono porcjami o tej samej wielkości, a lisy zwykle zjadały całą porcję. W teście chwytania lisy w klatkach standardowych łapano zwykle około 3 sekundy szybciej niż zwierzęta w klatkach wysokich. Najdłużej trwało chwytanie lisów w klatkach szerokich. Im większe lisy, tym dłużej trwało ich schwytanie. Przed skórowaniem łapanie trwało najdłużej w klatkach wysokich, a najkrócej w klatkach standardowych. Podczas chwytania lisy były w większości spokojne i ufne, szczególnie dotyczyło to zwierząt w klatkach wysokich. Zwierzęta były zdrowe przez cały okres badań, a mały obraz krwi świadczył o ogólnie dobrym zdrowiu we wszystkich grupach. Prawe i lewe nadnercza miały największą masę u lisów z klatek wysokich. Zadaszenia klatek można było łatwo podnosić. Choć drzwiczki tradycyjnie umieszczane są na dachu klatki, w naszym doświadczeniu musiały zostać umieszczone na przedniej ścianie klatki. Drzwiczki wymagają dopracowania. Podczas chwytania rosnących lisów druga osoba musiała trzymać drzwiczki, co wydłużało czas łapania. W klatkach szerokich dwoje drzwiczek umieszczano na jednym z końców klatki. Układ ten komplikował chwytanie, które przebiegałoby łatwiej, gdyby były tylko jedne drzwiczki na środku klatki. W konkluzji stwierdza się, że lisy niebieskie mogą być utrzymywane w klatkach, których ściany sięgają dachu pawilonu, nie stwarzając większych problemów produkcyjnych. Klatki wysokie pozwalają na wprowadzenie nowych rozwiązań technicznych celem poprawy dobrostanu lisów.