Effects of Digging Substrate on Growth and Fur in Blue Versus Shadow Type of *Alopex lagopus*

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Abstract. Our study sought to establish the extent to which digging substrate in the cage affects growth performance and fur properties in farmed foxes (*Alopex lagopus*) of the shadow white and blue colour types. The plates were on either the wall or the floor; the sandbox was always on the floor. A standard cage without any digging substrate was used as a control. There were 20 foxes in each group (one male and one female per cage). The cage setups were as follows: 1) a standard cage (105 cm long × 115 cm wide × 70 cm high) without digging substrates, which housed the control group; 2) a standard cage (105 cm long × 115 cm wide × 70 cm high) with a solid metal plate (210 × 297 mm) on the wall for digging and scratching; 3) a standard cage (105 cm long × 115 cm wide × 70 cm high) with a solid metal plate (210 × 297 mm) on the floor for digging and scratching; and 4) a standard cage (105 cm long × 115 cm wide × 70 cm high) with a metal sandbox for digging and scratching (80 × 40 × 14 cm, L×W×H). The sandbox had a 10 cm layer of sand (ca. 25 kg, particle size 0-18 mm) on the bottom. All animals grew well and reached normal body weights. No significant growth differences were found between blue and shadow types within the groups. Furthermore, skin length did not differ between colour types or between groups. Skin weight, on the other hand, was heavier in the blue than in the shadow type in the plate floor groups. No differences were recorded in the other groups. Fur quality was poorest in the blue type of the standard group and best in the shadow type of the plate wall group. Cover and mass were also best in the shadow type of the plate wall group. Furs were dirtiest in the sandbox groups, irrespective of colour type. Our findings tempt us to conclude that body growth is highly affected by digging substrate and that a sandbox in the cage causes the dirtiest fur and may, therefore, be avoided in farming practice.

Key Words: *Alopex lagopus*, digging substrate, fur properties, growth performance, colour type

Introduction

Recent European fur animal welfare recommendations stress the importance of providing farmed foxes with a stimulating housing environment that meets their species-specific needs (European Convention, 1999). A particularly urgent issue in fur farming management is clarification of foxes' need to dig (Harri et al., 1999; 2000; Hovland and Bakken, 2000; Korhonen et al., 2004; Koistinen et al., 2008; 2009a,b). Some European countries have already forbidden fox farming, as they consider that the cages currently in use neither give foxes an opportunity to practise digging behaviour nor permit them to have contact with concrete floor material. The decision to abandon fox farming, however, is not necessarily a result of research-based data.

Comprehensive research on the need for farmed foxes to dig and have contact with concrete floor material is currently under way. Several types of floor material, from wire netting to earth, have been tested for digging purposes (Harri et al., 2000; Koistinen and Mononen, 2008; Koistinen et al., 2007; 2008; 2009a,b; Korhonen et al., 2001; 2003). One solution is to provide foxes with an earthen substrate in a sandbox. Another is to fit a solid digging plate to the cage floor. However, both these substrates are problematic in that they are easily soiled (Korhonen and Huuki, 2011). Foxes prefer them as elimination sites. A third solution might be to fit the plate onto the wall, where it could not serve so easily as a defecation site. This solution would be reasonable if foxes were required not only to

be able to dig but also to make contact with a solid material with their feet.

One crucial question concerning concrete substrates is whether foxes need a solid floor exclusively or whether they should have at least some access to a solid substrate (Korhonen et al., 2001; 2003; 2004). In-depth studies on earthen enclosures versus cages with sandboxes covering part of the floor tempt us to conclude that floors fully covered with earthen material are not necessary. Furthermore, our previous paper (Korhonen and Huuki, 2011), which examined foxes' motivation to dig different substrates and small-piece plates, found that a digging plate on the wall is sufficient to satisfy the need for digging behaviour. The other key question is whether the floor material actually affects foxes' fur properties. How much more likely, for example, is the whiter colour type to get dirty and spoiled by concrete digging material than is the blue type? This is not yet known and, thus, the effects of digging a substrate on fur properties require further research.

We have sought here to establish the extent to which digging plates on the wall and floor and a sandbox in the cage affect the fur properties of farmed foxes (*Alopex lagopus*) of shadow and blue colour types. It would be expected that shadow white would be more sensitive to dirt and spoiling than a darker blue colour. Caged foxes without a digging substrate were used as a benchmark.

Materials and Methods

Subjects and experimental groups

The study was carried out at the Fur Farming Research Station of MTT Agrifood Research Finland, western Finland (63.54°N, 23.54°E). It comprised four experimental groups housed in four different cage setups: 1) a standard cage (105 cm long × 115 cm wide × 70 cm high) without digging substrates, which housed the control group; 2) a standard cage (105 cm long × 115 cm wide × 70 cm high) with a solid wooden plate (210 × 297 mm) on the wall for digging and scratching; 3) a standard cage (105 cm long × 115 cm wide × 70 cm high) with a solid wooden plate (210 × 297 mm) on the floor for digging and scratching; 4) a standard cage (105 cm long × 115 cm wide × 70 cm high) with a metal sandbox for digging and scratching (80 × 40 × 14 cm, L×W×H). The sandbox had a 10 cm layer of sand (ca. 25 kg, particle size 0-18 mm) on the bottom (Fig. 1).

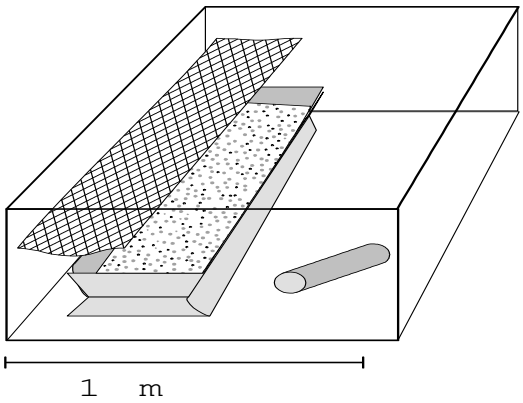

Figure 1. Layout of the experimental set-up in group 4. Sandbox (b) was placed below the wire-netting platform (a) in the cage. In each cage there was also a wooden block for chewing (c). In groups 2 and 3 the sandbox was replaced by wooden plate on the wall and floor, respectively. Group 1 had no digging substrate at all

The experimental groups were formed at weaning on 22nd July. Each group comprised 20 foxes (one male and one female per cage). At weaning, a platform (45 cm from the floor) and a wooden block for chewing (7 cm Ø × 35 cm long) were also placed in the cages. In group 2, the plate was fitted on the right-hand side of the cage, 30 cm from the base of the wall. In group 3, the plate was placed on the floor. Once or twice a day, the animals were fed equally large portions (750-1000 g daily) of fresh fox feed made by the local feed kitchen (Kannus Minkinrehu Ltd).

Measured variables and statistics

The animals were weighed four times during the experiment: at weaning on 22nd July, and on 3rd September, 1st October and 25th November.

Pelting took place on 25th November. The pelts were sent to Finnish Fur Sales, 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 analyses were conducted with the SAS system for Windows 9.1 and SAS Enterprise Guide 3.0. All variables that were normally distributed, and the homogeneity of variances was valid, were analysed with Mixed models. Pair-wise comparisons between experimental groups were performed with Tukey's test. The weight of an animal was used as a covariate in the analysis of organ weights. The weights of foxes and fur properties (weight, length, purity of colour, mass, coverage and quality) were analysed with the general linear model (GLM). Pair-wise comparisons were made with Tukey's test. The Kruskal-Wallis test was used to analyse the results for fur dirtiness. The pair-wise comparison was made according to Siegel and Castellan (1988).

Results and Discussion

The animals' appetite was good in all groups, and foxes typically ate all the feed provided. Initial body weights were of the same order of magnitude in all groups (Table 1). The animals grew well and reached normal body weights. Weighing did not reveal any significant differences between blue and shadow types within the digging-substrate groups, though there was a slight tendency ($P<0.1$) for the final body weights of blue types to be heavier, on average, than those of shadow types (14.2±1.1 vs 13.6±1.5 kg). Individual body weight variation was highest in the foxes with a sandbox. Lowest body weights averaged in shadow type of sandbox group. Skin length at pelting did not differ between colour types or between digging-substrate groups. In plate floor groups, however, skin weight at pelting was heavier ($P<0.05$) in blue than in shadow colour types (Table 1). In other groups, no differences were found.

The fur properties of the colour types are compared in Table 2. On average, quality was poorest in blue-type furs of the standard group and best in shadow-type furs of the plate wall group ($P<0.05$). Cover and mass were also best in the shadow-type of the plate wall group. In all groups, colour purity tended to be better in the blue than in the shadow fur type. Dirtiness was lowest in standard and plate wall groups ($P<0.05$), irrespective of colour type. Dirtiest were furs from sandbox group. However, any differences in dirtiness were found between colour types even in sandbox group.

Our previous studies (Korhonen et al., 2003; 2004; Korhonen and Huuki, 2011) showed that a digging plate is a suitable substrate for the performance of digging behaviour under farm conditions in foxes (*Alopex lagopus*). The amount of digging in the plate setup was found to be of the same order of magnitude as that in the sandbox. Furthermore, colour type of animal does not essentially affect the amount of digging in various substrates. However, the dirtiness of the digging substrate may be a crucial problem (Korhonen et al., 2003). In our previous study (Korhonen and Huuki, 2011), we found that both the sandbox and the floor digging plate get dirty within a few weeks because the foxes defecated and urinated on them. The motivation to eliminate was highest on sand material. The digging plate on the wall, on the other hand, remained clean throughout the study and was also used the most for digging. This finding is very encouraging, and was essential reason why to compare colour types and furs in the present study.

Large body size is a key goal in the commercial production of farmed fox furs (Hovland and Bakken, 2000). This is because skin and body lengths are typically highly related to the animals' pelting body weight (Korhonen and Harri, 1984). In our present study (Korhonen and Huuki, 2011), body

Table 1. Body weight (kg) and skin length (cm) and weight (kg) in blue (B) and shadow (S) type of blue foxes

Variable	Standard		Plate (wall)		Plate (floor)		Sendbox	
	B	S	B	S	B	S	B	S
Body weight								
July 22	2.1±0.3	2.1±0.2	2.1±1.4	2.0±0.2	2.1±0.2	1.9±0.2	2.0±0.2	1.9 ±0.2
Sept 3	6.2±0.6	5.9±0.4	6.0±0.4	6.1±0.4	6.2±0.5	5.7±0.4	5.9±0.3	5.7±0.7
Oct 11	9.1±0.4	9.8±0.8	9.6±0.7	9.5±0.6	9.3±0.8	9.6±0.9	8.8±1.1	9.3±1.1
Nov 25	14.1 ±1.1	13.6±1.1	14.1±1.1	14.7±1.1	14.3±1.5	13.7±1.2	13.9±1.3	12.7±2.3
Skin length	129±67	128±42	126±39	129±42	128±67	126±60	128±57	126±80
Skin weight	829±111	805±81	826±115	811±115	850±124	803±81[a]	827±82	806±159[a]

Skin length and weight was measured at pelting on Nov 25. [a]P<0.05 between the colour types within the group

Table 2. Fur properties in blue (B) and shadow (S) type of blue foxes.

Variable	Standard		Plate (wall)		Plate (floor)		Sendbox	
	B	S	B	S	B	S	B	S
Colour	3.8±1.6[a]	6.0±0	3.9±1.4	6.0±0	4.0±1.1[a]	6.0±0	4.0±1.4	5.4±1.3
Purity[1]	5.0±0.3	4.3±0.5	4.9±0.5	4.7±0.5	5.1±0.4	4.4±0.1[a]	5.1±0.6	4.6±0.5
Shade	379±58[b]	997±22	392±48[b]	1005±24	392±53[b]	998±26	393±48[b]	947±76
Mass	5.5±1.6	6.2±1.8	6.0±1.5	7.6±1.2	6.3±1.3	6.3±1.6	6.0±1.6	6.4±2.7
Cover	6.5±0.7	6.2±1.8	6.0±1.5	7.6±1.2	6.4±0.5	7.3±1.0	6.6±0.7	7.2±1.0
Quality	5.5±1.6	6.2±1.8	6.0±1.5	7.6±1.2	6.3±1.6	6.3±1.6	6.0±1.6	6.4±2.5
Dirtiness	1.0±0	1.0±0	1.1±0.3	1.1±0.3	1.5±0.7	1.6±0.9	1.9±0.7	2.1±1

[1]Purity of colour. [a]P<0.05 between the colour types within the group. [b]P<0.01 between the colour types within the group.

growth data demonstrated that foxes in all groups grew well, as was confirmed by the lack of a significant difference between groups at pelting. However, the fact that individual variation was highest in sandbox foxes and lowest average body weights were also found in animals having sandboxes suggests that sandboxes may have some adverse effects on animal size and growth. One potential explanation is that while sandboxes get dirty very quickly, they have adverse effects on animal. Dirty substrate may affect animals in several different ways, for instance, it is a good material for the growth of bacteria or parasites and so may have a negative impact on animal growth performance. Dirty substrate also soils the fur coat and thus lowers its thermal insulation (Korhonen et al., 2000). Increased heat loss requires extra energy, which may be at the cost of growth performance.

Our present findings showed that the sandbox, in particular, but also digging plate on floor soils the fur coat of blue foxes. Therefore, concrete material on cage floor is not suitable for digging substrate in commercial use. The actual problem here is that such furs fetch lower prices than clean furs at auctions. Our previous study (Korhonen and Huuki, 2011) demonstrated that plates on the wall are sufficient to satisfy foxes' need to dig under farm conditions. Present study additionally revealed that wall plates also keep the fur coat clean. Thus, such a digging substrate can be recommended in terms of animal welfare. They are also favoured from the farmers' point of view, as clean furs fetch the highest prices at auction.

The blue and white colour types of *Alopex lagopus* appear both in the wild and under farm conditions. On farms, the most common white type in Finland is shadow. The shadow colour phase is caused by an incompletely dominant, autosomal gene (Ness et al., 1989). The blue colour is a genetic variation in the wild Arctic fox. The blue type of *Alopex lagopus* is rare in the wild but most commonly produced fox type on farms. There are also other colour types of

farmed foxes, but in this study the two most common but otherwise very different in appearance was compared to get best possible contrast between furs. Our results did not reveal any dramatic difference in dirtiness between the colour types studied here. It would seem that the sandbox in particular is such a dirty substrate that colour variations in foxes' fur coats have little to do with the process of dirtiness, i.e. all kinds of furs are soiled when foxes have access to a sandbox. Parallel conclusion can be drawn from the use of floor plate. Thus, colour type does not protect a fur coat from getting dirty.

Conclusions

Our findings tempt us to conclude that body growth is highly affected by digging substrate and that a sandbox in the cage causes the dirtiest fur and may, therefore, be avoided in farming practice.

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