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Nest provision influences reproductive success in breeding blue fox vixens: a preliminary study

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Abstract

*The aim of the present study was to evaluate the effects of an unfamiliar nest and environmental enrichment, ie provision of an additional nest, on farmed blue fox (*Alopex lagopus*) vixens' reproductive performance. Two experimental groups were evaluated in the study: i) a single nest (SN) group where vixens had an unfamiliar top nest only, and ii) a group with two nests (TN), an unfamiliar top nest and a familiar floor nest. Since reproductive performance is typically lower in young blue fox vixens, half of the experimental animals consisted of primiparous vixens, to examine whether an unfamiliar and an additional nest affected primiparous and multiparous vixens' reproduction differently. No significant differences were found in reproductive performance between the experimental groups or between the primiparous and the multiparous vixens with the number of weaned cubs per inseminated vixen 4.8 (± 4.0) and 4.9 (± 4.5) for the primiparous and 5.6 (± 4.9) and 5.5 (± 4.6) for the multiparous vixens in SN and TN groups, respectively. In the multiparous vixens, the cub losses were higher in SN than in TN groups. The higher cub loss in the SN group may have been due to the lack of a familiar nest. In the TN group, where vixens had the opportunity to choose between two nest types, the majority (86%) of the primiparous vixens whelped in the floor nest, whereas the majority (73%) of the multiparous vixens favoured the unfamiliar top nest for whelping. Both nests were used by 43% of all TN vixens, a finding that indicates that an additional nest may have an enrichment value for blue fox vixens. The potential welfare consequences of providing blue fox vixens with an additional nest box should be investigated in future studies.*

Keywords: Alopex lagopus*, animal welfare, fox farming, reproduction, top nest,* Vulpes *spp*

Introduction

Farmed blue fox vixens are traditionally provided with only one wooden two-room nest for breeding, usually two weeks prior to the expected time of whelping (Mononen 1996). Typically, the nest is placed on the cage floor in the vixen's breeding cage, ie 50–100 cm above ground level. In contrast to farmed blue foxes, their wild relative, the arctic foxes (*Vulpes lagopus*) establish territories and dens long before whelping (Eberhardt *et al* 1983). Their dens are often located on hills with an unrestricted view over the denning area (Garrot *et al* 1983; Prestrud 1992). Moreover, arctic foxes are known to occasionally move their cubs from one den to another (Audet *et al* 2002) or to split their litter between several dens (Frafjord 1992). This type of behaviour reduces the risk of losing the entire litter to predators (Garrot & Eberhardt 1982) and reduces contact between siblings, decreasing potential disease transmission (Eberhardt *et al* 1983).

Under current commercial housing conditions, farmed blue foxes have no opportunity to choose their nest or transfer their cubs from one nest site to another. Previous studies have shown that farmed foxes use several nests if provided with the opportunity (blue fox: Jeppesen & Pedersen 1990; Korhonen & Niemelä 1996, silver fox (*Vulpes vulpes*): Pyykönen *et al* 1997, 2002a) which may indicate that an additional nest could be considered as an environmental enrichment. Top nests, ie nests situated on the top of the cages, are preferred by blue foxes as breeding sites (Jeppesen & Pedersen 1990). Furthermore, the reproductive success of both silver (Pyykönen *et al* 2002b) and blue (Mononen *et al* 1999) foxes provided with top nests has been shown to be as good as or even better than that achieved in foxes using traditional floor nests. Similar effects have been reported in foxes with tunnel nests (silver fox: Braastad 1994, blue fox: Haapanen *et al* 1990; Moss & Östberg 1985; Pyykönen *et al* 2009). Generally, the effect has been more pronounced in primiparous vixens with less benefit observed in multiparous vixens, which have already undergone selection for good reproductive characteristics but which also have previous whelping experience from other kinds of nests than those studied.

In the present study, we took into account the natural features of the denning behaviour of wild arctic foxes, ie elevated dens and the opportunity to choose between nests

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and to transfer cubs, and studied the reproductive consequences of having access to only an unfamiliar top nest or access to both an unfamiliar top nest and an additional, familiar, floor nest. To assess the vixens' use of the nests, we also recorded the location of their cubs in the group with access to two nests.

Materials and methods

The approval to conduct the present study was granted by the Institutional Animal Care and Use Committee of the University of Kuopio, Finland. The study was carried out at the Research Station of the University of Kuopio (Juankoski, Finland) during one breeding season in March–July 2000.

Animals and housing

Altogether, 25 artificially inseminated primiparous (aged 10–11 months at the beginning of the study) and 33 multiparous (aged 2–5 years) blue fox vixens, which had previous experience of only floor nests, were randomly selected for the study. The experimental vixens were divided into two groups: single nest (SN, n = 29, 14 primiparous and 15 multiparous vixens) and two nest (TN, n = 29, 11 primiparous and 18 multiparous vixens) taking into account the insemination date in order that vixens in both groups would be expected to whelp uniformly. As primiparous vixens generally whelp later than multiparous vixens, and less primiparous vixens are selected to the breeding stock, the number of primiparous and multiparous vixens differed between experimental groups. After insemination, vixens were moved to their breeding cages which measured 115 × 105 × 70 cm (length × width × height). All experimental vixens were housed in one two-row outdoor fur shed. SN and TN vixens were situated in every other cage and in both sides of the aisle. Therefore, all vixens had similar views over the farm.

Inside each cage, a plastic-covered, wire-mesh resting platform (30 cm wide) was hung about 25 cm from the ceiling. Two weeks before the expected time of whelping, the vixens in both groups were provided with access to an unfamiliar nest, the top nest with an anteroom (44 × 32 × 33 cm) and a main room (44 × 44 × 33 cm). There was a round opening (diameter, 20 cm) which permitted transfer between the two rooms. The front wall of the top nests could be opened which enabled the checking of nests and counting of cubs. The entrance (diameter, 20 cm) to the anteroom of the top nests was situated on the cage's ceiling over the resting platform. Access to the top nest was improved by provision of a wire mesh 'ladder' (105 × 30 cm; length × width) in all cages. These ladders sloped to the platform at angle of 50° and were especially useful for the cubs to climb from the cage floor to the platform. In the TN group, vixens were also provided with an additional breeding nest, a standard blue fox floor nest with an anteroom (43 × 30 × 37 cm) and a main room (43 × 45 × 37 cm). This nest was placed on the floor of each TN vixens' breeding cage.

As vixens are known to habituate easily to the checking of nests (Pyykönen 2008), the nests were inspected once a day during the last two prepartum weeks, to allow the vixens to become accustomed to the presence of humans. All nests were removed when the cubs were six weeks of age.

The experimental vixens were farmed according to traditional farming practices (see European Commission 2001) and fed in accordance with the Finnish recommendations (Finnish Fur Breeders' Association 2008) with commercial feed manufactured by the local feed centre (Ylä-Karjalan Rehu Oy, Valtimo, Finland). Drinking water was available *ad libitum*.

Measurements

During the experiment, one SN vixen died and one SN vixen became ill and was euthanised. Despite autopsies being carried out, no clear reasons for the losses were observed. In addition, a five-year old SN vixen rejected the top nest and whelped on the cage floor and was provided with a floor box. This vixen's data was excluded from the results and analyses. Accordingly, the total number of vixens was 26 (14 primiparous and 12 multiparous) and 29 (11 primiparous and 18 multiparous) in SN and TN group, respectively.

Blue fox vixens commonly eat their dead offspring (Pyykönen *et al* 2005) and thus only frequent counting can make it possible to analyse the early cub losses, which constitute most of the cub losses (Sanson & Farstad 2003; Pyykönen *et al* 2005). Therefore, the nests were inspected and the cubs counted three times a day, ie 0800–0900h, 1100–1200h and 1500–1600h from the day of whelping to the third day postpartum. On the days 7, 14 and 49 postpartum, the cubs were counted once a day. Based on the data from cub counting, new variables were formed: the number of barren vixens (Barren), ie inseminated vixens that did not deliver cubs, vixens that lost their entire litter, (Lost all) and vixens that succeeded to wean cubs, (Weaned). Reproductive performance, (RP) was measured as the total number of weaned cubs per inseminated vixen. In addition, the maximum number of cubs at birth (Litter $size_{max}$), live cubs at birth (Live cubs), cub losses during the first three postpartum days (Cub $losses_{0–3}$), from days 3 to 14 postpartum (Cub $losses_{3–14}$) and from days 14 to 49 postpartum (Cub $losses_{14–49}$), and cub losses from birth to weaning (Cub $losses_{0–49}$) were counted. The data from the two TN vixens that lost their entire litter at whelping were excluded from the analyses of cub losses, because the accurate number of live and dead cubs could not be estimated. The location of cubs was inspected only from the TN vixens that delivered and had live cubs on the first day postpartum, ie total of 21 vixens (7 primiparous and 14 multiparous). The location of cubs was recorded at the same time as the inspections of the nests and cub counting on days 0–28 postpartum (twelve inspections per vixen).

Statistical analysis

Statistical analyses were performed using the SPSS statistical package for Windows. *P*-values greater than 0.05 were not considered to be statistically significant (ns). Variables with normal distribution were analysed with parametric

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Table 1 Mean (± SD) or percentage reproductive data for the primiparous and multiparous vixens in the single nest (SN) and the two nest (TN) groups.

Variable	Primiparous (25)			Multiparous (30)		
	SN (14)	TN (11)	*P*-value[1]	SN (12)	TN (18)	*P*-value[2]
RP	4.8 (± 4.0)	4.9 (± 4.5)	> 0.05[a]	5.7 (± 4.9)	5.5 (± 4.6)	> 0.05[a]
Litter $size_{max}$	9.5 (± 3.8)	9.3 (± 3.6)	> 0.05[b]	10.6 (± 4.7)	8.1 (± 4.1)	> 0.05[b]
Live cubs	9.1 (± 3.4)	8.9 (± 3.3)	> 0.05[b]	9.9 (± 4.4)	7.8 (± 4.2)	> 0.05[b]
Cub $losses_{0-3}$	1.4 (± 1.8)	1.1 ± 1.3)	> 0.05[a]	2.5 (± 2.6)	0.6 (± 0.8)	> 0.01[a]
Cub $losses_{3-14}$	0.9 (± 1.2)	0.4 (± 0.5)	> 0.05[a]	1.4 (± 1.8)	1.1 (± 2.7)	> 0.05[a]
Cub $losses_{14-49}$	0.5 (± 1.7)	0 (± 0)	> 0.05[a]	0.5 (± 0.3)	0.1 (± 0.9)	> 0.05[a]
Cub $losses_{0-49}$	2.8 (± 3.1)	1.6 (± 1.3)	> 0.05[a]	4.5 (± 4.7)	1.9 (± 2.8)	> 0.05[a]
Barren	28.6% (4)	27.3% (3)	> 0.05[c]	8.3% (1)	5.6% (1)	> 0.05[c]
Lost all	0.0% (0)	9.0% (1)	> 0.05[c]	25.0% (3)	27.7% (5)	> 0.05[c]
Weaned	71.4% (10)	63.6% (7)	> 0.05[c]	66.7% (8)	66.7% (12)	> 0.05[c]

[a] Mann-Whitney *U*-test.
[b] GLM.
[c] Chi-square test.
[1] The difference between groups in the primiparous vixens.
[2] The difference between groups in the multiparous vixens.
RP: Cubs per mated vixen.

tests and variables with non-normal distribution with non-parametric tests. All data were analysed separately for the primiparous and the multiparous vixens. The results are presented as mean (± SD) or as percentages with number of animals in parenthesis. The differences in variables, Barren, Lost all and Weaned between groups within different age groups (primiparous and multiparous) and between primiparous and multiparous vixens (groups pooled) were analysed with the Chi-square test. The differences in variables Litter $size_{max}$ and Live cubs were analysed with General Linear Model (GLM) for Univariate measures. The differences in variables describing cub losses (Cub $losses_{0-3}$, Cub $losses_{3-14}$, Cub $losses_{14-49}$ and Cub $losses_{0-49}$) between the groups within different age groups were analysed with Mann-Whitney *U*-test and between the primiparous and the multiparous vixens with General Linear Model (GLM) for Univariate measures. The differences in RP between the groups within different age groups and between the primiparous and the multiparous vixens were analysed with the Mann-Whitney *U*-test.

Results

The provision of an unfamiliar nest had no clear effect on RP in blue foxes (see Table 1). In the primiparous vixens, no differences were found between the experimental groups in any of the measured parameters. In the multiparous vixens, the Cub $losses_{0-3}$ and Cub $losses_{0-49}$ were higher in SN than in TN (Table 1). No other differences in the measured parameters were observed between the experimental groups in the multiparous vixens.

In the TN group, ie where the vixens had the opportunity to choose between two nests (familiar and unfamiliar) the majority (six out of seven [86%]) of the primiparous vixens that whelped chose the floor nest for whelping whereas the majority (eleven out of 15 [73%]) of the multiparous TN vixens favoured the unfamiliar top nest. According to the inspection data, 43% of TN vixens (four primiparous out of seven and five multiparous out of 14) used both available nests at least once. Six vixens (4 primiparous and 2 multiparous vixens, respectively) moved cubs at least once, two vixens (both multiparous) at least twice, and one multiparous vixen at least four times. In addition, two litters of multiparous vixens were observed on days 7 and 14 postpartum to be split between the two available nests, ie some of the cubs were in the top nest and some in the floor nest.

In general, the multiparous vixens in this experiment had low RP while the primiparous vixens succeeded well with both housing systems (all ns). The losses of entire litters occurred most often for the multiparous vixens, since only one primiparous vixen lost an entire litter. The Litter $size_{max}$, number of live cubs, and cub losses in any of the periods analysed did not differ between the primiparous and multiparous vixens. In general, most of the deaths of the cubs occurred during the first two weeks postpartum. In all, 52% of the total cub losses occurred during the first three days postpartum and 89% of total cub losses had occurred two weeks postpartum (Table 1).

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Discussion

The aim of this study was to assess the effect of provision of an unfamiliar nest and an additional nest on reproductive performance in blue fox vixens.

An unfamiliar breeding nest did not affect reproductive performance, either in the primiparous or in the multiparous vixens. In the multiparous vixens, the cub losses were higher in the vixens with an unfamiliar top nest than in the vixens with two nests (familiar and unfamiliar). The higher cub losses in the multiparous vixens in the SN group may be attributable to the lack of a familiar nest. It has been shown that both blue and silver foxes tend to choose the nest type in which they themselves have been born (Jeppesen & Pedersen 1990). It is possible that the lack of a familiar nest and the lack of opportunity to choose a nest may have led to the higher peripartum cub losses in the multiparous SN vixens. To illustrate this possibility, one multiparous vixen in the SN group was never observed visiting the top nest. Ultimately, she delivered her cubs on the cage floor. Accordingly, the present results reveal that multiparous vixens should not be suddenly provided with a new nest type but should first be habituated to an unfamiliar nest with the presence of a familiar nest. It is also likely that two nests might increase the foxes' control over their living environment within the cage. When the vixens feel secure, they are known to behave calmly and to stay with cubs at their most vulnerable age (Braastad 1994). The awareness of an additional, and in this case familiar nest, could have provided the vixens with a better sense of control and security which has been shown to reduce stress and, subsequently, to increase reproductive success (cf Broom & Johnson 1993). Accordingly, one could hypothesise that the welfare of the females and their offspring could be enhanced with access to an additional nest.

Despite the higher cub losses in multiparous vixens in the SN group, the multiparous vixens preferred the top nest to the floor nest when they had the opportunity to choose between the two nest types. The choice of the multiparous vixens was surprising since they had no previous whelping experience with top nests, and early experiences have been shown to affect the animals' later preferences and behaviour (Broom & Johnson 1993). The present results may indicate that if provided with a choice, the option chosen by a vixen with previous whelping experience on only floor nests may be based on criteria other than early experience, ie the top nest provided a better view to monitor the farm environment (Pedersen & Jeppesen 1993).

Although the additional nest did not confer any advantage in terms of reproductive success, the additional nest may have had positive effects in terms of animal welfare. When vixens were able to move their cubs from one nest to another, almost half used the opportunity at least once. In addition, two vixens split their litters between the two nests. This behaviour resembles that of wild arctic foxes, with the exception that the transferring of cubs in farmed blue foxes occurred earlier than that reported in the arctic foxes (Frafjord 1991, 1992). Accordingly, an additional nest enables species-specific behaviour. However, due to the possible confounding effect of previous nest experience, larger-scale experiments are needed to investigate the motivational basis for using an additional nest and for assessing the possible benefits to welfare.

Conclusion

An unfamiliar nest did not affect reproductive performance in blue fox vixens. However, lack of a familiar nest may induce cub losses. The opportunity to choose between two nests and to move cubs from one nest to another was used frequently, indicating that an additional nest may have some enrichment value for blue fox vixens. The potential welfare consequences of providing blue fox vixens with an additional nest should be investigated in future studies.

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References

Audet AM, Robbins CB and Larivière S 2002 *Alopex lagopus. Mammalian Species 713*: 1-10

Braastad BO 1994 Reproduction in silver fox vixens in breeding boxes with and without an entrance tunnel. *Acta Agriculturae Scandinavica, Section A, Animal Science 44*: 38-42

Broom DM and Johnson KG 1993 *Stress and Animal Welfare, First Edition*. Chapman & Hall: London, UK

Eberhardt LE, Garrott RA and Hanson WC 1983 Den use by arctic foxes in Northern Alaska. *Journal of Mammalogy 64*: 97-102

European Commission 2001 The Welfare of Animals Kept for Fur Production. *Report of the Scientific Committee of Animal Health and Animal Welfare*. Brussels, Belgium

Finnish Fur Breeders' Association 2008 *Ravintoainesuositukset 2007*. http://www.stkl-fpf.fi/modules/system/stdreq.aspx?P=59&VID=default&SID=213921969388321&S=0&C=24861. [Title translation: Recommendations for fur animal feeding]

Frafjord K 1991 Adult arctic foxes *Alopex lagopus* (L) in the denning area; numbers and behaviour. *Fauna Norvegica, Series A12*: 41-48

Frafjord K 1992 Denning behaviour and activity of arctic fox *Alopex lagopus* pups: Implications of food availability. *Polar Biology 12*: 707-712

Garrot RA and Eberhardt LE 1982 Mortality of arctic fox pups in northern Alaska. *Journal of Mammalogy 63*: 173-174

Garrot RA, Eberhardt LE and Hanson WC 1983 Arctic fox den identification and characteristics in northern Alaska. *Canadian Journal of Zoology 61*: 423-426

Haapanen K, Harri M, Mononen J, Korhonen H, Niemelä P, Rouvinen K and Fors F 1990 Lymodellens och andra miljöfaktorers inverka på blårävens valpresultat. In: *Proceedings from the NJF-Seminar No 185* pp 10. 19-21 September 1990, Copenhagen, Denmark. [Title translation: Effect of nest types and other environmental factors on the reproduction of farmed blue foxes]

Jeppesen LL and Pedersen V 1990 Improvement of management routines and cage systems in fox production. *Scientifur 14*: 237-242

https://doi.org/10.1017/S0962728600001226 Published online by Cambridge University Press

Korhonen H and Niemelä P 1996 Effect of environmental and social enrichment on some welfare variables in farm blue foxes (*Alopex lagopus*). *Scientifur 20*: 26-34

Mononen J 1996 Resting platforms and nest boxes for farmed blue foxes (*Alopex lagopus*) and silver foxes (*Vulpes vulpes*). The extent of use, reasons for use and welfare effects. *Kuopio University Publications C. Natural and Environmental Sciences 52*: 62

Mononen J, Harri M, Sepponen J, Korhonen H, Rekilä T and Ahola L 1999 A top box and a floor box as breeding nest boxes in farmed blue foxes (*Alopex lagopus*): reproductive performance, use of the boxes and cub carrying. *Acta Agriculturae Scandinavica, Section A, Animal Science 49*: 206-210

Moss S and Östberg G 1985 Lyförsök med blåräv 1984. *Finsk Pälstidskrift 19*: 120-121. [Title translation: Nest experiment in the blue fox 1984]

Pedersen V and Jeppesen LL 1993 Daytime use of various types of whole-year shelters in farmed silver foxes (*Vulpes vulpes)* and blue foxes (*Alopex lagopus)*. *Applied Animal Behaviour Science 36*: 259-273

Prestrud P 1992 Physical characteristics of arctic fox (*Alopex lagopus*) dens in Svalbard. *Arctic 45*: 154-158

Pyykönen T, Ahola L, Jalkanen L and Harri M 1997 Behaviour of silver foxes (*Vulpes vulpes*) in ground floor enclosures. *Proceedings from the Nordic Association of Agricultural Scientists* pp 125-131. 6-8 October 1997, Helsinki, Finland

Pyykönen T, Ahola L, Mononen J, Mohaibes M and Kasanen S 2002a Parental behaviour of group-housed farmed silver foxes in semi-natural environment. In: Koene P (ed) *Proceedings of the 36th International Congress of the International Society for Applied Ethology* pp 214. 6-10 August 2002, Egmond aan Zee, The Netherlands

Pyykönen T, Asikainen J, Miettinen M, Mononen J, Sepponen J and Ahola L 2002b Breeding success of farmed silver foxes with top boxes. *Proceedings from the Nordic Association of Agricultural Scientists*, *Fur* pp 127-132. 2-4 October, 2002, Vuokatti, Finland

Pyykönen T, Mononen J, Ahola L and Rekilä T 2005 Periparturient behaviour in farmed blue foxes (*Alopex lagopus*). *Applied Animal Behaviour Science 94*: 133-147

Pyykönen T 2008 Environmental factors and reproduction in farmed blue fox (*Alopex lagopus*) vixens. *Kuopio University Publications C. Natural and Environmental Sciences 242*: 78

Pyykönen T, Ahola L and Mononen J 2009 A note on the reproduction of primiparous blue fox vixens in social groups. *Animal Reproduction Science 112*: 409-414

Sanson GH and Farstad W 2003 Perinatal pup loss in the blue fox (*Alopex lagopus*), Review and historical data. *Proceedings from the Nordic Association of Agricultural Scientists* pp 6. 8-10 October 2003, Lillehammer, Norway

https://doi.org/10.1017/S0962728600001226 Published online by Cambridge University Press