BEHAVIOUR OF SILVER FOXES IN TRADITIONAL BREEDING BOXES AND IN BOXES WITH AN ENTRANCE TUNNEL

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The periparturient behaviour of silver-fox females inside traditional and modified breeding boxes was video-recorded. The behaviour was analysed from 24 hours before parturition to 72 hours after, and in three diurnal periods. Twenty litters had the traditional simple breeding box, whereas 14 litters had a box with a narrow entrance tunnel. Compared to females in traditional boxes, females in tunnel boxes spent more time sleeping inside the box both before and after parturition, cleaning newborn cubs and grooming cubs while lying down, but less time looking out of the box. Excavation performed on the floor prior to parturition was performed equally often in both box types. The differences between box types were particularly pronounced for primiparous vixens. During the three postparturient days most differences in behaviour between box types were only found during working hours (0800–1500h). At this time females in non-tunnel boxes spent considerably less time sleeping and more time in locomotion within the box, looking out of the box, walking into or out of the box, standing partly out of the box, or staying out of the box, than females in tunnel boxes. Cub mortality was lower in tunnel boxes than in non-tunnel boxes. The results indicate that females in tunnel boxes had a more relaxed behaviour and were able to nurture their offspring more effectively. They did not watch their surroundings as frequently as females in traditional breeding boxes. Giving silver foxes a breeding box with an entrance tunnel may improve the welfare of both female and offspring.

Keywords: *animal welfare, housing, maternal behaviour, nest, reproduction, silver fox*

Introduction

The reproduction of farmed silver foxes (*Vulpes vulpes* L.) is known to vary considerably, both between farms and between individual vixens (females) within a farm. Cub mortality is perhaps the most critical factor in this reproduction. During the last decade, several projects on fox behaviour have aimed at revealing the causes of this variation and finding appropriate measures to improve the reproduction, as reviewed by Braastad (1992) and Bakken *et al* (1994). Such measures are often likely to improve the welfare of both vixens and cubs. Studies in our department have revealed a pronounced effect of social status, measured as competition capacity, on reproduction of silver foxes (Bakken 1993a); low status vixens rarely breed if their nearest neighbours are of high status (Bakken 1993b).

The physical environment is another factor that could reduce reproduction and welfare, for example due to the unfortunate effect of the design of the cage or the breeding box on the behaviour of the foxes. Newborn carnivores are heterothermic. The body temperature of young cubs is much more dependent on the presence of their mother than on the insulation properties of the breeding box (Harri *et al* 1989). The body temperature will decrease as soon as the vixen leaves the breeding box (Harri *et al* 1991). Therefore it is important to ensure that the breeding box serves the needs of the vixen, such that she chooses to lie down inside with only short trips out of the box. Vixens which lose their cubs are more often standing and less often resting inside the breeding box than successfully reproducing vixens (Braastad & Bakken 1993). Since the traditional breeding box on farms is quite simple in design, we decided to compare the periparturient behaviour of vixens in traditional and in more complex boxes.

In nature, red fox *(Vulpes vulpes)* dens usually consist of one or more small nests connected to the outer area with one or more narrow tunnels through which no larger predator can enter (Grassé 1955 p 218-220). Blue foxes (*Alopex lagopus*) reproduce better if the breeding boxes have an entrance tunnel (Moss & Östberg 1985). We therefore designed breeding boxes for silver foxes, all of which had a tunnel.

The hypothesis of the present study was that silver fox vixens are calmer and take better care of their newborn cubs if their breeding boxes are provided with an entrance tunnel.

Material and methods

Animals and housing

During 1984-1990, a study was carried out on 38 litters from 36 silver fox vixens from the Agricultural University fur farm. Descriptions of the normal periparturient behaviour (Braastad 1993) and of infanticide in these foxes (Braastad & Bakken 1993) have been reported previously. Four of the multiparous vixens were selected because they had been infanticidal in earlier years; two of these had a litter in each of the two types of boxes in this study. The other vixens were selected at random from the breeding population. In this paper behavioural data for 34 litters will be presented, 18 from primiparous vixens and 16 from 2-7 year-old multiparous (experienced) vixens (only three vixens were older than 4 years). Four recordings were omitted: three because of missing times and dates in the video pictures, and one because of birth complications. Reproductive success, however, was analysed for all 38 litters.

Each vixen was kept in a traditional cage system, consisting of an empty wire-netting cage with mesh floor of $1.4m^2$ (130x108cm (B x D) in a two-row, or 160x90cm in a four-row, fox house), and a breeding box placed in a neighbouring cage so that the vixen only had access to the box and not the rest of the cage (Figure 1). The animals were cared for according to common practice by skilled personnel. Rations of well-balanced mash food were given daily between 1200h and 1300h, while water was available *ad libitum*.

Twenty of the breeding boxes (11 for primiparous and nine for multiparous vixens) were of the traditional type with an inner nest area of about 43x45x37cm and an anteroom of 43x(28-35)x37cm, without a separating wall (non-tunnel box, or NT box; Figure 2, left). Fourteen boxes (seven for primiparous and seven for multiparous vixens) had a narrow entrance tunnel measuring 18x20cm in cross section (tunnel box, or T box). Details of their design varied, but one practical type is shown in Figure 2 (right). All boxes were made of

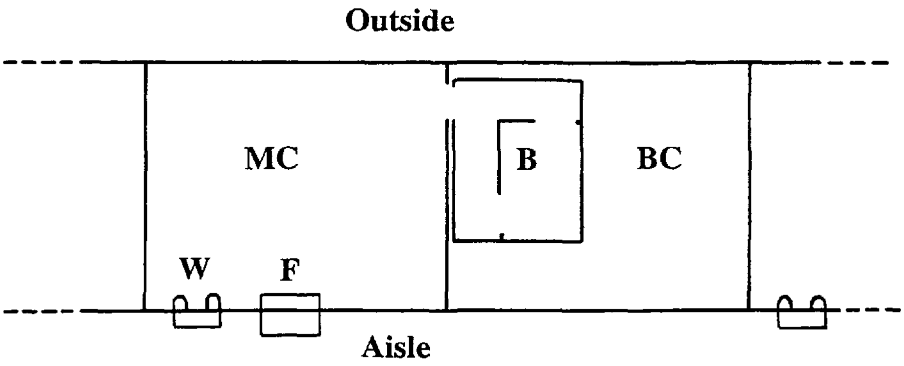

Figure 1 Cage system – with two cages each measuring 130x108cm per female, one main cage (MC) with food (F) and water (W), and one breeding box cage (BC) with only access to the breeding box (B). A similar cage row is found at the other side of the aisle.

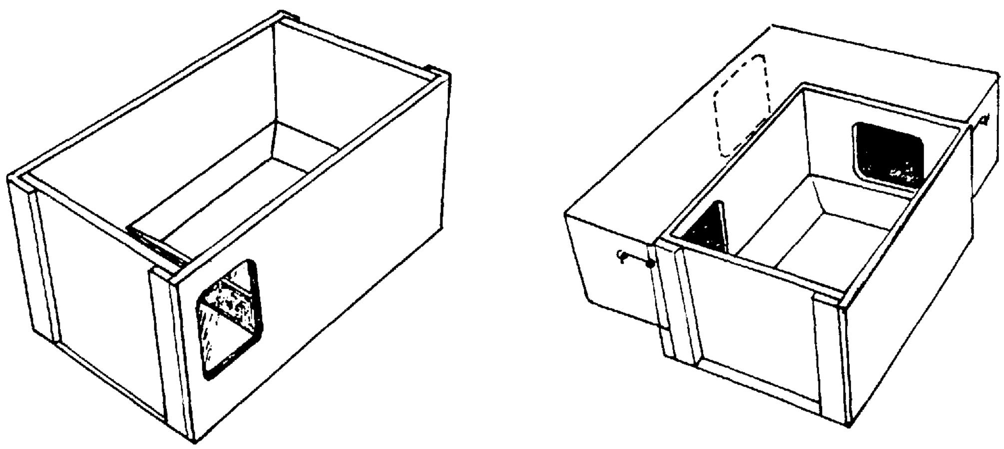

Figure 2 The main types of breeding boxes used in this study. Left: traditional box (non-tunnel box). Right: experimental box with exits through a tunnel measuring 18x20cm in cross section (tunnel box).

wood and had a plastic foam plate (styrofoam) beneath the floor to improve insulation. Annual samples, dates and variation in ambient mean daily temperatures for the 34 analysed subjects are shown in Table 1. Temperatures were measured at an official weather station 900m from the research farm. The fox cages were well protected from strong winds and precipitation.

Table 1 **Number of litters in non-tunnel (NT) and tunnel boxes (T), ranges of birth dates and ambient mean daily temperatures (1984–1989).**

Year	Number of litters in NT	Numbers of litters in T	Birth dates	Mean daily maximum and minimum temperatures
1984	4	0	18.04–11.05	3.4–10.8
1985	1	3	19.04–11.05	0.3–13.0
1986	0	4	08.04–08.05	-2.3–9.5
1987	4	7	14.04–29.05	2.6–14.1
1988	8	0	22.04–15.05	-0.8–16.2
1989	3	0	12.05–22.05	7.1–15.3
Mean ± SD for days when NT boxes were tested				7.9 ± 3.3
Mean ± SD for days when T boxes were tested				6.7 ± 3.5

Behaviour categories

Fifteen different behavioural states in the vixen were defined (Braastad 1993). A distinction between resting and sleeping was made in order to record two degrees of immobility: resting defined as lying down immobile, but with at least small head movements during the last 5min, and sleeping defined as lying down totally immobile without head movements during the last 5min. Excavating on floor, was digging on the box floor with forelimbs. Five categories of cub-care were defined, with the vixen lying down or standing. Congregating cubs consisted of moving circularly in a lying position to assemble cubs into one group. Since suckling could not be observed directly, it is included in either resting or sleeping. The remaining behaviour categories presented in the tables should be self-explanatory.

Recording and analyses

The periparturient behaviour of the vixens inside the breeding box was recorded with an Ultricon-tubed video camera mounted in a specially designed camera box (Braastad 1993) on top of the breeding box. Two infrared light sources made filming possible both day and night. A time-lapse video recorder with a speed of about four frames per second was used.

Quantitative analysis of the videotapes was made by instantaneous sampling of one behavioural state (Lehner 1979) exactly every 5min, from 24 hours prior to the onset of parturition to 72 hours after the last cub was born, using The Observer software (supplied by Noldus Information Technology, Wageningen; Noldus 1991).

Separate calculations of individual time budgets were made for three different phases: the last 24 hours prior to birth (preparturition phase); the parturition phase from birth of the first cub to the time the last cub had been born and licked dry; and the first 72 hours after the parturition phase (postparturition phase). For the analysis of the parturition phase, five litters with only one cub were omitted because the duration of parturition was too short. For vixens which lost the whole litter, observations were stopped when all cubs had died. Since this occurred soon after birth in five litters, only 29 litters (15 in non-tunnel boxes, 14 in tunnel boxes) were included in the analysis of the postparturition phase. Time-budgets were also calculated for three diurnal periods in the postparturition phase: 0801–1500h (working hours), 1501–2100h (evening), and 2101–0800h (night). Summertime (1 hour advanced) is used, with true midnight at 0114h. Sunrise varied between 0412h and 0623h, whereas sunset varied between 2017h and 2218h. According to our experience, foxes are inactive until people arrive on the farm.

Statistics

Untransformed means and standard deviations are presented in the tables. Statistical analyses and tests were made by general linear models (GLM) in the SAS system after transforming the time-budget data (in percentages) according to the formula: $y = \arcsin\sqrt{x/100}$ (Zar 1974; Statistical Analysis Systems Institute Inc 1986). Initial analysis showed that neither house type, month of birth nor daily ambient mean, minimum or maximum temperature ever affected any behaviour category significantly when parity and box type were included in the model. A few tendencies to temperature effects are reported in the Results section. The data on reproductive success and time-budget of behaviour were therefore analysed with a model with parity (primiparous or multiparous), box type (tunnel or non-tunnel), and their interactions as independent class variables. The analysis of behaviour according to time of day was performed with a model with parity, box type, time of day, and interaction between time of day and box type as independent class variables. To avoid statistical problems with the selection of subjects, the two age categories were also analysed separately.

Results

Reproductive success

In non-tunnel boxes and tunnel boxes, respectively, litter sizes at birth were 4.5 ± 0.3 and 4.1 ± 0.4 cubs (ns), litter sizes at seven days were 2.2 ± 0.4 and 3.4 ± 0.5 cubs ($P = 0.06$), and mortality during the first week was 2.3 ± 0.4 and 0.5 ± 0.5 cubs ($P = 0.006$). The reduced mortality in tunnel boxes was significant also for primiparous vixens separately ($P = 0.04$). Among the 34 vixens included in the behaviour analysis, the parturition phase lasted 215 ± 134min in non-tunnel boxes and 171 ± 91min in tunnel boxes (ns), whereas the intervals between successive births were 58 ± 29min and 57 ± 34min in the two box types, respectively. The births were distributed over the three diurnal periods roughly in proportion to the relative lengths of these periods (9, 7 and 18 births, respectively).

In the traditional non-tunnel boxes 15 of 22 litters were subjected to infanticide of one or more cubs or rejection of the whole litter, whereas in tunnel boxes only 3 of 16 litters experienced this ($P = 0.006$, Fisher's exact probability test).

Behaviour in different periparturient phases

In the preparturition and parturition phases resting was slightly reduced with increasing daily mean temperature, whereas in the postparturition phase vixens were looking slightly more out of the box with increasing temperature ($P = 0.08$–0.09). No other effects on behaviour of daily mean, minimum or maximum temperature were found. Since the average outside temperature did not differ between the days when the different box types were used (Table 1), the weather conditions were not considered to affect the conclusions to be drawn.

Tables 2–4 show the time-budget of behaviour in non-tunnel and tunnel boxes for the three periparturient phases, separately for primiparous and multiparous vixens. During the last day before parturition, primiparous vixens in tunnel boxes slept more and groomed themselves more inside the box than those in non-tunnel boxes (Table 2). The latter vixens went more into and out of the box and stayed more out of it. Excavating on floor was done with the same fraction of time in both types of breeding boxes. The preparturient behaviour of experienced vixens did not differ between box types.

Table 2 Time-budget of behaviour during the 24 hours preceding parturition (preparturition phase) among primiparous and multiparous silver fox vixens inside breeding boxes with (T) and without (NT) an entrance tunnel (percentage of observations, M ± SD).

Behaviour category	Primiparous		Multiparous		All
	NT	T	NT	T	
	n = 11	n = 7	n = 9	n = 7	n = 34
Resting	13.3 ± 8.7	18.3 ± 5.8	14.8 ± 8.6	18.2 ± 5.7	
Sleeping	12.9 ± 12.4	28.1 ± 7.9*	19.8 ± 13.8	22.7 ± 5.8	*
Excavating on floor	8.7 ± 6.7	8.3 ± 4.4	5.2 ± 4.0	5.7 ± 1.9	
Labour and genital licking	1.7 ± 1.2	2.0 ± 1.2	0.8 ± 0.7	1.0 ± 0.7	
Self-grooming	2.8 ± 2.7	5.6 ± 2.8*	2.8 ± 2.5	2.2 ± 1.6	
Looking out of box	4.5 ± 4.1	4.1 ± 3.0	3.2 ± 3.5	3.4 ± 2.2	
Locomotory within box	2.1 ± 1.5	2.5 ± 1.3	1.6 ± 1.1	2.2 ± 1.3	
Walking into or out of box	1.6 ± 1.0	0.5 ± 0.8**	1.6 ± 1.4	0.8 ± 0.6	**
Staying out of box	48.4 ± 24.4	27.2 ± 15.6(*)	47.9 ± 27.9	42.9 ± 12.4	

Significant differences between box types, based on generalized linear models with arcsin-transformed variables, are indicated for each parity group and for all vixens (*) $P < 0.06$, * $P < 0.05$, ** $P < 0.01$.

Table 3 Time-budget of behaviour during the parturition phase among silver fox vixens inside breeding boxes with (T) and without (NT) an entrance tunnel (percentage of observations, M ± SD).

Behaviour category	Primiparous		Multiparous		All
	NT	T	NT	T	
	n = 8	n = 5	n = 9	n = 7	n = 29
Resting	13.8 ± 9.6	11.2 ± 10.5	16.6 ± 11.6	13.8 ± 9.5	
Sleeping	5.0 ± 6.6	0.0 ± 0.0*	3.0 ± 6.5	1.7 ± 3.1	(*)
Excavating on floor	1.3 ± 1.9	0.7 ± 1.0	0.1 ± 0.3	2.6 ± 5.1	
Labour and genital licking	10.6 ± 5.2	18.4 ± 8.3(*)	25.2 ± 14.6	14.2 ± 10.6	
Cub-care, total	40.9 ± 15.0	60.7 ± 8.6	41.1 ± 15.0	59.7 ± 14.6	**
Cleaning newborn cubs	16.8 ± 7.8	25.7 ± 13.2	20.7 ± 9.1	32.4 ± 12.3	*
Cub-grooming, lying	14.2 ± 12.1	26.3 ± 7.8	17.1 ± 8.3	21.0 ± 13.1	
Cub-grooming, standing	4.7 ± 4.9	4.0 ± 5.1	0.2 ± 0.5	0.7 ± 1.8	
Inspecting cubs, lying	3.6 ± 4.9	2.6 ± 3.5	1.9 ± 2.7	3.9 ± 3.3	
Congregating cubs	0.9 ± 1.8	1.7 ± 3.9	0.5 ± 1.4	1.7 ± 2.3	
Self-grooming	4.6 ± 4.0	1.2 ± 2.6 *	0.5 ± 1.2	1.9 ± 3.3	
Looking out of box	4.6 ± 5.9	0.9 ± 1.2	3.3 ± 3.2	0.0 ± 0.0**	**
Locomotory within box	2.0 ± 2.2	2.2 ± 3.4	2.0 ± 2.9	0.2 ± 0.6	
Walking into or out of box	1.5 ± 2.4	0.4 ± 0.9	0.5 ± 1.4	0.4 ± 1.2	
Staying out of box	6.7 ± 7.9	4.0 ± 5.5	7.4 ± 14.8	0.9 ± 1.5	

Significant differences between box types, based on generalized linear models with arcsin-transformed variables, are indicated for each parity group and for all vixens (*) $P < 0.07$, * $P < 0.05$, ** $P < 0.01$.

During the parturition phase, regardless of age, vixens in tunnel boxes spent considerably more time caring for cubs than in non-tunnel boxes (Table 3). This consisted of more cleaning of the newborn cubs and more grooming of cubs while lying down. Vixens in tunnel boxes also slept less and looked less out of the box.

During the first three days after the parturition phase, vixens in tunnel boxes slept more than vixens in boxes without entrance tunnels (Table 4). Primiparous vixens instead rested more without sleeping, in non-tunnel boxes. These inexperienced vixens spent more time caring for cubs in tunnel boxes than in non-tunnel boxes, more time grooming cubs lying and more time congregating cubs. Vixens in non-tunnel boxes looked more out of the box and moved more within the box than vixens in tunnel boxes.

Table 4 Time-budget of behaviour during the 72 hours after the parturition phase (postparturition phase) among silver fox vixens inside breeding boxes with (T) and without (NT) an entrance tunnel (percentage of observations, M ± SD).

Behaviour category	Primiparous		Multiparous		All
	NT n = 6	T n = 7	NT n = 9	T n = 7	n = 29
Resting	35.1 ± 5.6	25.5 ± 4.4**	31.7 ± 5.3	30.6 ± 5.6	*
Sleeping	30.4 ± 6.4	40.4 ± 7.3*	33.3 ± 7.9	42.2 ± 8.5*	**
Excavating on floor	0.1 ± 0.2	0.7 ± 1.3	0.5 ± 1.1	0.3 ± 0.5	
Cub-care, total	16.4 ± 4.2	24.2 ± 4.8*	20.8 ± 5.6	20.4 ± 4.2	*
Cub-grooming, lying	11.9 ± 4.0	18.6 ± 4.2*	15.5 ± 3.8	16.6 ± 3.9	*
Cub-grooming, standing	0.7 ± 0.6	0.9 ± 0.8	0.6 ± 0.4	0.4 ± 0.5	
Inspecting cubs, lying	2.9 ± 0.9	3.3 ± 1.4	2.7 ± 2.0	2.2 ± 1.4	
Congregating cubs	0.3 ± 0.3	0.9 ± 0.4**	0.7 ± 0.4	0.6 ± 0.5	*
Self-grooming	0.5 ± 0.4	0.6 ± 0.6	0.3 ± 0.3	0.1 ± 0.1	
Looking out of box	5.3 ± 3.2	3.1 ± 3.0	5.6 ± 4.3	1.4 ± 0.5*	**
Locomotory within box	0.9 ± 0.2	0.6 ± 0.5	1.4 ± 1.0	0.7 ± 0.6(*)	*
Walking into or out of box	0.5 ± 0.3	0.2 ± 0.2	0.8 ± 0.4	0.6 ± 0.5	
Staying out of box	10.0 ± 12.7	3.8 ± 4.2	4.0 ± 2.0	3.9 ± 2.5	

Significant differences between box types, based on generalized linear models with arcsin-transformed variables, are indicated for each parity group and for all vixens (*) $P < 0.06$, *$P < 0.05$, **$P < 0.05$.

Behaviour in different diurnal periods

For three diurnal periods during the postparturition phase, Table 5 shows the percentages of time spent in those behaviour categories which showed a significant interaction between box type and time of day. In addition, resting was included for comparison with sleeping.

Table 5 **Time-budget of some behaviour patterns for different diurnal periods during the postparturition phase among silver fox vixens inside breeding boxes with (T, n = 14) and without (NT, n = 15) an entrance tunnel (percentage of observations, M ± SD).**

Behaviour category	Working hours (0801-1500h)		Evening (1501-2100h)		Night (2101-0800h)	
	NT	T	NT	T	NT	T
Resting	35.4±9.5	29.7±5.8*	34.0±6.3	29.6±6.8	31.3±5.4	26.1±5.6*
Sleeping	17.8±10.2	39.5±10.9***	37.1±10.0	38.3±9.4	39.2±10.8	43.6±9.2
Locomotory within box	1.8±1.0	0.6±0.4***	0.8±0.8	0.5±0.6	1.0±1.0	0.7±0.8
Looking out of box	10.5±7.2	3.3±4.0***	4.7±3.7	2.8±3.6	2.7±2.7	1.2±1.7
Standing partly out of box	2.7±4.6	0.7±1.5*	1.3±2.9	0.0±0.1*	0.9±1.6	0.0±0.1(*)
Walking into or out of box	1.0±0.7	0.4±0.5*	0.3±0.4	0.6±0.9	0.7±0.7	0.3±0.4
Staying out of box	12.4±17.6	4.5±4.6**	5.0±3.8	4.9±4.8	2.8±2.8	2.8±2.5
Percentage of cub care performed lying down	83.9±9.7	90.6±5.4*	89.9±8.1	89.9±7.1	90.4±7.8	92.9±3.4

Significant differences between box types, based on generalized linear models with arcsin-transformed variables, are indicated for each parity group and for all vixens (*) $P < 0.06$, *$P < 0.05$, **$P < 0.05$.

Most differences between box types were found during the working hours. During this period vixens in non-tunnel boxes slept only half as much as during the other periods. During working hours primiparous vixens slept only 12.5 ± 4.6 per cent of the time (range 5.3–18.4 %) in non-tunnel boxes, but 38.7 ± 11.8 per cent of the time (range 19.8–59.1 %) in tunnel boxes ($P < 0.0001$). The reduced sleeping in non-tunnel boxes during working hours was associated with more time spent staying out of the box, looking out of the box, showing restlessness (locomotory within the box, standing partly out of the box, or walking into or out of the box), and resting with head movements. Compared with evening and night, respectively, during working hours the vixens in non-tunnel boxes spent more time locomotory within the box ($P = 0.001$, $P < 0.05$), looking out of the box ($P < 0.01$, $P < 0.001$), walking into or out of the box ($P < 0.01$, ns), and staying out of the box ($P < 0.05$, $P < 0.001$). While vixens in non-tunnel boxes cared for their cubs equally frequently in all diurnal periods, they performed the cub care more often in a standing position during working hours than during the other diurnal periods ($P < 0.05$, $P < 0.05$), probably reflecting the higher restlessness.

Vixens in tunnel boxes showed no significant differences in behaviour between the diurnal periods. Even sleeping was performed with about the same fraction of time both day and night.

Discussion

In several respects, the periparturient behaviour of silver-fox vixens, and particularly of the primiparous ones, differed between the traditional and the modified breeding boxes.

Vixens in breeding boxes with an entrance tunnel more often slept in the box after parturition, also before parturition as regards the primiparous ones. After parturition in boxes without a tunnel, primiparous vixens instead rested more without sleeping. Considering the definitions of resting and sleeping, this shows that vixens in tunnel boxes were lying immobile on average for a longer period of time, indicating that they were less often disturbed or motivated to check certain circumstances. Yet these vixens spent more time grooming cubs than vixens in non-tunnel boxes. Grooming is often elicited by cubs crawling around. The extra disturbance perceived by vixens in non-tunnel boxes may be assumed to come from outside the breeding box. This is supported by the observation that, particularly during working hours, vixens in these boxes more often stood partly out of the box, walked into or out of the box, and stayed out of the box.

The excavation on the box floor was equally frequent in tunnel and non-tunnel boxes. This behaviour is performed by all vixens during the preparturition phase (Braastad 1993) and may be an obligatory element of the birth-preparation behaviour programme, for example with the function of removing surface material and perhaps make a shallow depression on the ground, which was observed in red foxes by Naaktgeboren (1965).

Vixens in non-tunnel boxes showed a marked diurnal variation in their time-budget of behaviour, with less sleeping and more engagement with events outside their breeding boxes during working hours. This was not found in vixens in tunnel boxes, which suggests that such diurnal variation in behaviour may not be a normal species-specific character during the first postparturient days. Cubs are born at any time of the day or night, and they demand care and nourishment quite frequently, so the vixen seldom can sleep continuously for more than an hour (Braastad 1993). Most vixens in non-tunnel boxes managed to groom their cubs with a normal frequency also during working hours, indicating the high priority of this behaviour, although the grooming was more often performed in a standing position. High frequency of standing is associated with a high probability of infanticide (Braastad & Bakken 1993). Since much attention had to be paid to outer circumstances in this period, sleeping had to be given a relatively low priority. However, the vixens did not compensate for this lack of sleep at other times of the day or night.

The reasons for the increased attention to external events during working hours among vixens in non-tunnel boxes, could be related either to the activities of the working staff or to the neighbouring animals. A human was present in each shed only for a total of about 15-30 minutes per day, so close contact with the staff could hardly explain the observed effect. However, the presence of the staff in the farm increases the general activity of at least those foxes which have no offspring in their cage. Around noon this is probably related to an anticipation of being fed. The animals may hear noise from the feed kitchen. At this time of day mink are reported to show more stereotypies (de Jonge *et al* 1986). The increased general activity may stimulate vixens in simple, non-tunnel boxes to regularly watch what is going on. The fact that this did not apply to the vixens in tunnel boxes to the same extent, indicates that the latter vixens felt more secure.

The lower cub mortality in tunnel boxes also indicates improvement of the maternal behaviour in these boxes, as the tunnel *per se* does not improve the insulation of the breeding box (Harri *et al* 1989). Particularly the primiparous vixens managed to stay with their cubs more constantly, hence making decreased body temperature in the cubs less likely to occur. In a large-scale experiment on nine private fur farms, the decreased cub mortality in tunnel boxes was confirmed and was particularly significant for primiparous vixens (Braastad 1994). Therefore, studies on both behaviour and reproductive success show that it may be important especially for the inexperienced vixens to have a more concealed nest. Since poorly reproducing farm vixens may show higher fearfulness (Braastad 1988; Bakken 1992), it is possible that a tunnel box improves their self-confidence and makes them feel more secure. The lower frequency of infanticide in the tunnel boxes also supports this (Braastad & Bakken 1993). It is possible that a more secluded nest enables vixens with low social status to reproduce normally. This may be related to the observation that low status vixens which lost their litter in the previous year, managed to breed more successfully if they were spatially and visually more isolated from their neighbours (Bakken 1993a). High status vixens may be expected to reproduce equally well in simple and modified breeding boxes, but this remains to be tested.

In a small-scale choice test in 1992, in which 15 multiparous vixens could choose between the two box types presented in Figure 2, 12 of them chose the tunnel box while only three vixens chose the non-tunnel box, despite the fact that almost all vixens had only experienced the latter box in previous years (Braastad unpublished data). Although a tunnel box may be preferred by most vixens, the design of the box is not the only important factor. Choice tests have shown that silver fox vixens prefer a breeding box mounted on top of the cage to a box in other positions (Jeppesen & Pedersen 1990). Opening the box to expose the cubs better to humans after 2 weeks of age may be important to reduce later fear responses of the cubs towards humans (Pedersen 1991). This may be especially important with tunnel boxes, and is easily done by removing the tunnel part of the box.

Conclusions

Providing silver fox vixens with a breeding box with a narrow entrance tunnel may ensure a more relaxed behaviour, and allow the vixen to concentrate on nurturing her offspring rather than watching events in the surroundings of her cage. The results were particularly clear for inexperienced, primiparous vixens. These effects may be the reason for the decreased cub mortality which was found in tunnel boxes (Braastad 1994).

Animal welfare implications

The welfare of farmed fur bearers is frequently questioned. The research during the last years has shown that the welfare of particularly the silver foxes could be improved by simple measures. This paper shows that in breeding boxes with an entrance tunnel, both reproductive success and maternal behaviour can be improved, presumably by increasing the feeling of security in a more secluded nest. It can also be argued from these results that the welfare of the females and their offspring is also enhanced.

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