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Original article

Evaluation of the relationship between social status and reproductive performance in farmed blue foxes

H Korhonen, P Niemelä

Agricultural Research Centre of Finland, Fur Farming Research Station, SF-69100 Kannus, Finland

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Summary — An experimental cage system was designed for evaluating the association of social status and reproductive performance in blue foxes under fur-farm conditions. The present test cage apparatus consisted of 6 small cages and 1 large cage that were connected. The small cages were utilized for males of different social status and the large cage for females coming on heat. The results showed that this type of testing apparatus can be used for evaluating a female's acceptance of males of different social rank. The locomotor activity of males significantly depended on their social status; thus the most active individuals in the test were the most dominant, and *vice versa*. Females most often accepted higher-ranking males. Juvenile males were the least dominant and also the least accepted by females. Urination activity was not necessarily related to dominance.

mating / preference / reproduction / social status / blue fox / fur farming

Résumé — Mesure des relations entre le rang social et les performances de reproduction chez les renards bleus d'élevage. *Une cage expérimentale a été mise au point pour étudier les relations entre le rang social et les performances de reproduction chez les renards bleus en élevage. Cette cage consiste en 6 petits compartiments contigus (74 x 107 cm) et un grand compartiment (52 x 480 cm) disposé contre l'extrémité des petits (fig 1). Les petites cages reçoivent chacune un mâle de rang social donné et la grande, une femelle en œstrus. Les résultats montrent que cet équipement peut être utilisé pour évaluer les capacités d'acceptation par une femelle de mâles de rang social différent. L'activité locomotrice des mâles dépend significativement de leur rang social : les individus les plus actifs au cours du test sont les plus dominants, et inversement. Les femelles acceptent le plus souvent les mâles qui marquent beaucoup leur territoire (jet d'urine). Les jeunes mâles sont les moins dominants et aussi les moins acceptés par les femelles. Le marquage par l'urine n'est pas nécessairement relié au statut de dominance.*

comportement / reproduction / rang social / renard bleu / fourrure d'élevage

INTRODUCTION

Conclusive evidence now exists that wild red and arctic foxes are more social than had previously been considered (Hersteinsson and MacDonald, 1982; Eberhardt *et al*, 1983; Garrot *et al*, 1984; Frafjord, 1991). Recently, this has also been partly confirmed by experiments carried out both in ground enclosures (Wakely and Mallory, 1988; Angerbjörn *et al* 1991; Korhonen and Alasuutari, 1992) and under commercial shade-house conditions (Bakken, 1990). These observations additionally support the conclusion that a marked relationship exists between social dominance and reproductive performance. Thus individuals of higher social status obviously have a better whelping result and fewer kit losses than animals of lower status, and *vice versa*.

It is a known fact that farm-raised fox vixens at estrus do not accept all the males offered to them. Nevertheless, no definitive explanation has been given as to why some males are rejected and others not. Recent sociability studies, however, support the conclusion that mating preference is in relation to an animal's social status. To further clarify this hypothesis, a special cage system was designed to test the dominance preference of farmed blue foxes during the breeding season.

MATERIALS AND METHODS

The experiments were carried out at the Fur Farming Research Station of Kannus in western Finland. During the autumn of 1991 the experimental blue foxes used were selected and allocated into 7 different dominance groups. Each group consisted of 2 juvenile and 3 adult males. The criterion for male reproductive performance was the number of offspring. Thus, the animals were selected so that each group had 1 good breeder, 1 medium-quality breeder and 1 poor breeder. Each group was housed separately from the other groups. The social status of each male was estimated by testing its dominance towards other group-mates, as described by Bakken (1988).

In February 1992, 3 dominance groups which exhibited the clearest ranking order were selected for the experiments, and 3 similar dominance test cage systems were constructed. Each test system comprised 6 small cages (74 cm wide x 107 cm long) and 1 long cage (480 cm long x 52 cm wide). The small cages housed the 5 males, and the long cage 1 female on heat (fig 1). This arrangement provided the female with free and close access to each of the separate males in the system. The aim was to test to what extent the social status of the male affected the mating preference of the female studied when given the freedom to select her partner. The test cage system included an empty cage as a control.

Two different types of test were conducted: 1) long-term tests; and 2) short-term tests

Long-term test

These experiments were carried out from March 17th to April 11th. The same male group was exlusively used (group 3) during the entire test period (table I). These males were kept in the testing cage (fig 1) according to following order (from left to right): 15, 14 ,13, 12, 11; thus the rank order was as follows: 5, 4, 2, 1, 3 (table 1). The males were accustomed to the test situation for 2 wk prior to the testing period. The test was started by first weighing the males. After this, they were all returned to their own cages in the test system. Then, the female was put in the long cage. She was on heat, and ≈ 2 d before

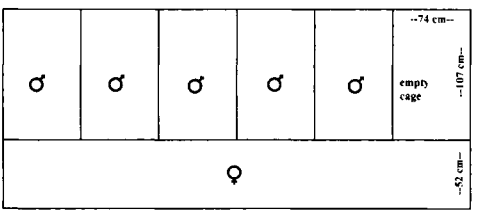

Fig 1. Schematic presentation of the present test cage system used.

Table I. Summary of the testing results in male groups.

Group/ Male	*Social status* [a]	*Maturity* [b]	*♂ marking activity* [c]	*♀urination to ♂* [c]	*♀close to ♂* [c]	*♀ mating reaction* [c]
Group 1						
1	3	A	+	+	++	+
2	1	A	+–	++	+	+
3	2	A	++	+–	+–	++
4	4	J	– –	–	– –	+–
5	5	J	–	– –	–	+–
Group 2						
6	3	A	++	++	+	+–
7	1	A	–	+	–	+
8	2	A	– –	–	+–	++
9	4	J	+	+–	+–	+–
10	5	J	+–	+–	++	– –
Group 3						
11	3	A	++	+	–	
12	1	A	++	–	+	
13	2	A	– –	– –	–	
14	4	J	+	–	–	
15	5	J	+	++	++	

[a] Social status: 1: most dominant; 5: least dominant. [b] A: adult; J: juvenile. [c] + and – indicate the amount of the reaction.

her estimated estrus peak. The estrus stage was determined by measuring the electrical resistance of that female's vaginal tract daily (Möller, 1980). Each female was tested for 5 consecutive d. The body weights as well as the feed consumption of the test female and the experimental males were measured. Urine marking behaviour was also monitored. The behavior of the animals in the test system was recorded with video camera equipment (CDD video camera 720, Bische UB-480 tape recorder, Koyo monitor, Bische 12-300 infrared light: 500 W).

Short-term tests

These experiments lasted from March 23rd to April 3rd. Two different male groups (1,2) were used for the testing. The housing order of the males in the test cages (fig 1) was the same as their numerical order. Their rank orders are given in table I. The female whose estrus had just begun was placed in the cage system for 1 h to find out which of the males she would select. The behavior of the animals was recorded on video.

There was no filiation relation between the animals tested; neither had there been any previous mutual contact between the males and females, nor had they been in proximity before the tests.

The data were statistically treated by analysis of variance, regression analysis and by Pearson's and Spearman's correlations.

RESULTS

Body weight and feed intake

The weight loss throughout the experimental periods was the lowest ($p < 0.05$) in

males M-13 (820 g) and M-15 (920 g). The weight loss of the other males range between 1 540 and 1 610 g. No statistical relationship ($p > 0.05$) was found between weight loss and social status.

Feed consumption among the males varied significantly ($p < 0.05$). Juvenile males (M-14, M-15) ate well all the time (400 g/animal/d). However, the appetite of the adult males varied, being on average 175–275 g/animal/d. The most dominant individuals ate less, and *vice versa* ($p < 0.01$).

Locomotor activity

The male that was estimated to have highest social status (M-12), was also the most active ($p < 0.01$); on an average it moved 733 ± 119 min/24 h (mean ± SD). Correspondingly, the male with the lowest social status (M-15) was the least active (302 ± 115 min/24 h). The mean daily locomotor activity among the other males (M-11, M-13, M-14) varied between 396 and 577 min ($p < 0.05$). There was a significant relationship between male social status and locomotor activity ($p < 0.01$). The locomotor activity of the females varied between 328 and 571 min/24 h ($p < 0.05$).

Marking activity with urine

The monitoring of marking behavior (urination) in males was started already 2 wk before testing any female. At that time, no urine marking or casting towards the empty female cage occurred. However, the first signs of marking were observed soon after the female was placed in the test cage. In addition, there were noticeable differences in marking activity between the males ($p < 0.05$). The most active markers were M-11 (rank 3) and M-12 (rank 1) (table I), which clearly made their presence known by urinating in reaction to each of females tested. M-13 (rank 2) was the least active urine marker, urinating in reaction to only 1 of the 6 females. M-14 (rank 4) and M-15 (rank 5) were between the least and the most active level. No statistical significance ($p > 0.05$) was found between marking activity and social status of the study animals.

All the females urinated close to the cage of male M-15 (the lowest in social rank). On the other hand, none of females urinated close to M-13 (rank 2). A statistically significant ($p < 0.05$), but negative relationship was found between male social status and female marking activity.

Behavior of females towards males

The females in the long-term experiments were most interested in the lowest-ranking male, M-15 (staying close to his cage on average 582 min/5-d period). They also slept almost exclusively close to the cage of M-15 (3866 min/5-d period). Among the other males no differences were noted concerning demonstration of interest in them (staying time 165–288 min//5-d period). Also the extra empty cage interested the females for about the same time (*ie* 193 min/5-d period) as males 11–14. On an average the females slept close to the empty cage for 152 min and close to males 11–14 for 80 min during the 5-d period.

Willingness to mate

The females' mating acceptance was tested only in the short-term experiments (table II). There was a marked relationship between the mating willingness of females and the social status of males; the females most often accepted those males with the

Table II. Basic data for the adult females (F) tested with males of groups 1 and 2.

Female	*Testing day*	*Electrical resistance* [a]	*Mating reaction towards male* [b]				
Group 1			1	2	3	4	5
F–35	23.3	940	–	+	++	–	–
F–52	23.3	380	+	+	+	–	–
F–53	24.3	900	+	+	+	–	–
F–56	25.3	180	+	+	+	+	+
F–50	26.3	380	+	+	+	+	+
F–37	27.3	140	+	+	+	+	+
F–51	30.3	320	+	+	+	+	+
F–23	1.4	460	+	+	+	+	+
F–22	2.4	380	+	+	+	+	+
F–70	3.4	460	+	+	+	–	–
Group 2			6	7	8	9	10
F–49	23.3	180	–	+	+	–	–
F–32	25.3	140	–	+	+	–	–
F–48	25.3	460	+	+	++	+	–
F–47	26.3	520	+	++	++	–	–
F–54	27.3	120	–	+	+	–	–
F–34	27.3	180	+	+	+	+	–
F–25	30.3	220	–	+	+	+	–
F–26	31.3	320	+	+	+	+	–
F–58	2.4	200	–	+	++	–	–
F–39	3.4	640	+	+	+	+	–

[a] Electrical resistance of vaginal tract is given in ohm. [b] Females' mating preference to each male after testing is marked as follows: – indicates that the female rejected the male, + means that the female accepted the male. Numbers 1–5 are the males of group 1, and numbers 6–10 are the males of group 2.

highest social rank ($p < 0.05$). In both groups, the females did not eagerly accept the juvenile males.

Behavior in short-term experiments

Videotapes were used to calculate how much time the females tested spent close to each male. The results for group 1 are as follows: the most popular male was M-1 in whose vicinity the females spent 36.8% of their test time. Next were M-2 (20.9%) and M-3 (12.6%), respectively. The juvenile males were the least popular; M-5 (11.7%) and M-4 (9.1%). The females spent 8.9% of their time near the empty cage.

During the entire test period the males in group 1 urinated in reaction to the females 632 times, the percentages for M-3, M-1 and M-2 being 39.4, 32.1 and 27.4% respectively. The juveniles were the least active urine markers: M-5 (0.8%) and M-4 (0.3%).

The females in group 1 urine-marked during the entire test period 233 times, the proximities to M-2, M-1, M-3 being 43.3,

20.7 and 18.9%, respectively. The juveniles least often marked by the females were M-4 (11.2%) and M-5 (5.6%).

The results for group 2 are as follows: the percentages of time spent by the females close to the cage of M-10, 6, 8, 9, 7 were 31.0, 20.0, 15.4, 15.3 and 12.5%, respectively. The empty cage was favored by 5.8%. The males in group 2 urine-marked clearly less (379 times) compared to those in group 1 (632). The urinating activity of the males in group 2 was divided as follows: M-6, 42.0%, M-9, 29.5%, M-10, 16.3%; M-7, 9.8%; and M-8, 2.4%.

The females in group 2 urine-marked 210 times throughout the entire test period. Most often, the females urinated close to the cage of M-6 (38.1%). The females urinated close to the rest of the males as follows: M-7, 20.1%, M-10, 15.2%; M-9, 14.3%; and M-8, 9.0%. The marking percentage of the empty cage at this time was then 3.3%.

DISCUSSION

The results showed that under standard farm conditions there are foxes of different social status. This supports the previous findings both in blue foxes (Wakely and Mallory, 1988; Angerbjörn *et al*, 1991; Korhonen and Alasuutari, 1992) and silver foxes (Bakken, 1990). Thus it is obvious that sociability, which is common in wild foxes, is also present in individuals under captive conditions.

Results on female to male proximity are somewhat difficult to analyze because of the different relationships in the 3 groups. However, it is obvious that sociability is not only expressed by dominance and that search for proximity is related to other factors such as age. Especially in groups 2 and 3, females were closer to juvenile than adult males.

The results provided clear evidence that the locomotor activity of males depends on their social status. This had also been previously documented in silver foxes by Bakken (1990). Our previous experiments (Korhonen and Alasuutari, 1992) conducted on blue foxes housed in large enclosures also support the same conclusion. Thus, it is obvious that the most dominant males can be detected by their locomotor activity, especially just prior to and during the breeding season. The results of long-term experiments showed that the females on heat also selected males, and most often accepted only the most active and dominant males.

Our previous observations (Korhonen and Alasuutari, 1992) on large enclosures support the conclusion that urination activity is connected with an animal's social status. However, the present results concerning marking behavior and urination activity were partly ambiguous. For instance, it is difficult to determine why the females most often urinated close to the cage of the lowest ranking male, M-15, in the long-term experiment. In the short-term experiments as well, urination behavior was somewhat controversial, and was not always in relation to social status. Thus, obviously female and male urinary marking is initiated and located by factors other than only dominance.

It is interesting to note that sexual preferences for a given male are connected with his rank, although males and females did not live together at the time of testing but in individual neighbouring cages. Moreover, the results clearly show the existence of and some reasons for sexual preferences in females. Particularly in groups 1 and 2 it was observed that females preferentially look for dominant males. This is of high practical significance and should be taken into account on fur-farms. Features of females' sexual preference have also been observed in group-living foxes both in large

enclosures (Korhonen and Alasuutari, 1992) and in the wild (Hersteinsson and MacDonald, 1982). Thus, it is obvious that preferential behavior generally has a marked importance for this species.

The present experiment constituted an attempt to devise a testing system by which the existence of social rank order in farmed foxes could be studied. Although it was possible to estimate the effect of social status on the foxes' reproductive performance, more studies are needed to improve the testing system, thus making it also suitable for practical farming use.

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