

# Adult Arctic Foxes *Alopex lagopus* L. in the denning area; numbers and behaviour

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Behaviour of Arctic Foxes *Alopex lagopus* in the denning area was studied in two mountain regions of southern Scandinavia. More than two adult foxes were recorded in 6 of the 9 den-years in Scandinavia. One den probably contained two litters of pups and two pairs of adults, while two more dens may have contained two litters. Several adults probably visited dens only briefly, and more than two adults were rarely observed at the same time. Some spatial separation of adults was also found. Since parenthood of pups was unknown, and since the role of the «surplus» adults was not clear, they could not be assigned a «helper» role. Surplus adults in the denning area may have resulted from a relaxed territorial defence, rather than from a need for more adults to bring food to pups.

Interactions between adults were rarely observed, and were mainly restricted to the transfer of food from male to female. Adults were mostly resting when observed in denning areas, and were inactive 60–90% of the time. Females and males were not different in their overall activity, with mean  $73 \pm 15\%$  of their time being inactive. Male activity varied significantly with time of day, but female activity did not.

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## INTRODUCTION

Group-living in small and medium-sized carnivores has largely been explained by the dispersion of food resources in space and time (e.g. Macdonald 1981, Schantz 1984, Lindström 1986, 1989). In Red Foxes *Vulpes vulpes* groups are considered territorial and usually consist of a pair and one or more offspring (Macdonald 1980, Schantz 1984). These offspring are most frequently thought to be subadult females, and they may assist in the rearing of their parents' new litter of pups, thereby acting as «helpers».

Only few studies have included observations of adult foxes and their behaviour at den sites, but most of those who have conclude that surplus adults are sometimes found at Arctic Fox *Alopex lagopus* dens (Eberhardt et al. 1983, Frafjord 1984, Hersteinsson 1984, Ovsyanikov 1987). Some old reports indicate that more than one litter may be born in the same den (Collett 1912, Johnsen 1957). Both male and female Arctic Foxes bring food to the young at about equal frequency (Garrott et al. 1984).

The Arctic Fox has been used in compara-

tive studies of social organization in carnivores (e.g. Bekoff & Daniels 1984), and is interesting because it lives in an extreme environment with highly variable food supplies both within and between years. However, little information is available on social organization and behaviour of the species. Monitoring fox populations by surveying breeding dens has become important in the management of the species in Scandinavia (e.g. Ericson 1984), and information on the behaviour of foxes is essential to design adequate surveys (Garrott et al. 1984). In the present paper I describe the numbers, behaviour, and activity of adult Arctic Foxes at breeding dens in the mountains of South Norway and Sweden.

## STUDY AREAS AND METHODS

I studied the behaviour of Arctic Foxes at three breeding dens in South Norway (Finse, den I) and along the Norway-Sweden border (Sylane, den II and III). Study areas and foxes have been described previously (Frafjord 1984, 1986, 1988, 1989). Voles and lem-

mings are present in both areas and probably constituted the main prey of foxes, but waders, passerines or ptarmigan may have been important prey in years of low rodent numbers. Most observations were made during May to September in the years 1981 and 1982, with additional observations in the years 1983—1986. Observations were made from a blind at distances 150—300 m from the den. Some information on pups and adults in Sylane in 1986 and 1988 was given by I. Kirkvoll (pers. comm.).

Adult foxes were identified according to sex, colour type, seasonal moult of pelage (which is highly variable between individuals), size, and general appearance. An individual code consists of one letter describing sex (F = female, M = male), and a number identifying pairs (foxes with same number).

Observational sampling was done on a 1-minute (1981 and 1982) or 5-minute (1983—1985) scheme both day and night, and social interactions were noted opportunistically whenever possible. One observation of one fox was termed a «fix». Behaviours recorded were described by Frafjord (1984, 1986). The denning area was defined as the region of the primary (natal) den and successive (secondary) dens (den I and III) used by a fox family, but it was impossible to observe foxes throughout their entire home ranges.

One-way ANOVA was used to examine the relationship between fox inactivity and time of day, and Cochran's C calculated to evaluate homogeneity of variances. In every ANOVA the individual fox was the sampling unit.

## RESULTS

### Adult numbers in the denning area

Adults were observed in 9 den-years during 1981—1988 (Table 1). In 6 (67%) of these den-years more than 2 adults were observed. Both sexes were represented as «surplus» adults, and were observed both when pups were present or absent. Some surplus adults visited the den only briefly, but most were observed several times or during prolonged periods (Table 2). One den was probably inhabited by two fox families (den III—85, Table 1), where both females had visible nipples indicating that they had nursed pups. In two other dens (I—81 and II—82) two litters may have been born. More adults were observed in years of high abundance of voles and lemmings than in years of low abundance (Table 1), but the sample size is too small to permit statistical analysis.

More than two adults were rarely observed at the same time, indicating some kind of temporal segregation between foxes. Some spatial separation was also found, due to different use of primary and secondary dens by some adults. In den I—81 the male M1 was only observed at the natal den, while M2 was only observed at the secondary den. (M1 was twice observed near the secondary den.) The same was apparently the case at den III-84 for the males M7 and M8. The two females F1 and F2 were observed during different periods, as F1 left the den after the emergence of F2 and the pups. Only one interaction between them were observed, even though earlier both were apparently using the same den with only one entrance.

Table 1. Periods of observation, individual codes (foxes for which behavioural data are presented), and numbers of adult Arctic Foxes observed at three dens in Scandinavia. U = Unknown sex, H = years of high lemming population.

Den-year	Periods of observation	♂♂	♀♀	U	Total	Pups
I-81	3-15.6/23.6-11.8/18.8-16.9	M1, M2	F1, F2	1*	5	+ H
II-82	16-17.5/20.6-15.8	M4	F3, F4		3	+
II-83	12-16.5/4-6.6/17.6	1	1		2	-
II-84	5-6.5/25-27.5/15.6-4.7/29.7	M5	F5	1	3	-
II-85	6-8.6/17-23.6/28.6/1.7/25-27.8	M6	F6		2	+ H
II-86	1-2.5/15.6/?			1	1	+*
II-88 <sup>†</sup>	27.4/10.8			3	3	+ H
III-84	21-28.8/18-19.9	M7, M8	F7		3	+
III-85	18.5/20.6/30.6/29-31.8	2	2		4	+ H

\* Ø. Pedersen, pers. comm.

† I. Kirkvoll, pers. comm.

Table 2. Percent of time during which adult foxes were observed at dens in southern Scandinavia for different age groups of pups. Lines indicate percentage for several groups, due to fewer observations. Total number of fixes for each fox is also given.

Fox	Prior no. birth	Age of pups in days								No. of fixes
		1-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	
F1		0.6								29
F2			8.6	6.6	1.9	—0.02—				1583
F3	3.3									16
F4			20.9	12.5	19.7	—21.8—				2820
F5	4.4*									158
F6		—21.7—								632
F7					8.2					98
M1		23.5						—71.2—		2487
M2					—1.6—					388
M4	97.3		8.8	14.3	21.5	7.6				2606
M5	11.4*									418
M6		—26.0—								759
M7					8.9					106
M8					5.3					63

\* No pups

Female F3 at den II—82 was only observed prior to birth of the pups (Table 2), but she was definitely pregnant. Because only one more known den in the region at quite a distance from den II was inhabited by foxes this summer (Ericson 1984, J. Ericson pers. comm.), it is unlikely that this female gave birth somewhere else. The second female at this den (F4) nursed only some pups, whereas she chased others away.

#### Adult presence at dens

Adult foxes were usually observed only a small part of the day, rarely more than 20% (Table 2). Comparisons of the behaviour of various individuals were difficult because few were observed during the same time periods (i.e. age group of pups) and because sampling intensity varied. Most reliable comparisons can be made between females F2 and F4, and F2 was observed for less than half the time as F4 (Table 2). Female F2 substantially reduced her time at the den as the pups grew older. F4 appeared to visit the den more frequently at first, but abandoned her den earlier than F2 (Table 2). The male partner of F4 (M4) was frequently observed throughout the breeding period, comparable to his mate. No clear sexual differences in time observed at dens was seen, except that

females were rarely seen until the emergence of pups at the age of 21 days.

Females F5 and F6 were observed at the same den during two successive years, and were most likely the same individual. The same applies to males M5 and M6. F5 and M5 were frequently observed at the den (Table 2), although no pups emerged this year. The emergence of pups was rather late the next year (about 30 June), but both F6 and M6 were observed outside the den more than 20% of the time prior to pup emergence (Table 2). This was rather unusual for a female. Because her nipples were visible she was probably nursing pups. F6 was a white and M6 a blue fox. The colour distribution among pups was 1 blue to 10 white. The probability of this combination of parents and pups is very low ( $p = 0.0054$ , binomial distribution, assuming that the blue male was heterozygote). Thus, the possibility that the female had also mated with a second male should not be ruled out.

Male M1 was regularly found at the natal den until pups emerged, but thereafter only infrequently until the pups were 70—90 days old (Table 2). His departure may have resulted from his mate (F1) abandoning the den. When pups were mainly independent of both dens and adults a male fox (most likely M1) stayed for many days at the den, mainly during daytime. He both played with pups and gave them food.

Table 3. Percentage of fixes devoted to different behaviours by adult Arctic Foxes observed at dens in southern Scandinavia. No data means that the behaviour was not observed in the fox, + means that the percentage was between 0.1 and 0.5%.

Behaviour	Females							Males							
	F1	F2	F3	F4	F5	F6	F7	M1	M2	M4	M5	M6	M7	M8	
Lie	10	63		60	35	56	83	88	68	83	32	73	70	73	
Sit	17	6		15	8	8	3	1	3	3	15	5	11	13	
Stand	7	7		3	13	5		1	2	2	10	5	4	2	
Walk/trot	28	7	56	8	22	14	8	2	7	4	18	4	10	11	
Gallop	14	5		7	13	4	4	3	11	5	7	9	1		
Flee	17			+		+		+			+	+			
Groom	4	2	6	2	1	1		2	1	1	10	2	4	2	
Urinate		+	6	+	1	+		+	+	+	+				
Defecate			+	25	+		+	+	+	+	+	+			
Nurse		4			3										
Eat	7	1		+	3	8		+		1	2		+		
Drink/Eat snow		+		+		1				+		+			
Cache food				+	2	1				+		+	1		
Habituate pups to solid food		2													
Feed other fox		1		1		+	1	+	2	1	2	1			
Secure food	4			+		1									
Chase away pup		2		2			1	+	3	1					
Carry pup		+													
Social interactions	7	+		+	4	1		+	+	+	1				
Social play				+					2						
Hunt		+		+				+	3	+					
Interactions with red fox				+							+				

### Behaviour

Adult foxes were lying most of the time they were observed at the den (Table 3). Sit, stand, walk, and gallop were next in frequency, while other behaviours rarely exceeded 5% (Table 3). Two females were observed to nurse pups, and F2 and F4 nursed pups 3.5 and 3.0% of the time respectively (Table 3). Nursing was observed until pups were 35 and 45 days old in F2 and F4 respectively, declining with time (Table 4).

Table 4. Percent of fixes that two females were nursing pups during 10-days period.

	Age of pups (days)			
	21-30	31-40	41-50	n
F2	6.8	3.5	0.0	84
F4	2.7	8.2	0.3	56

Both males and females fed pups and brought food to the den about equal number of times (a total of 41 observations in males including his feeding of the female, 40 in females). The increase in number of fixes F2 was observed to feed pups (Table 5) resulted from her weaning the pups, while the pups of F4 and M4 already seemed to eat solid food when observations were started. Most of their pups left the den at an early age (about 40 days old) which may explain the apparent

Table 5. Percent of fixes that two females and one male fed pups during 10-days periods (also including male delivering of food to the female).

	Age of pups (days)				
	21-30	31-40	41-50	>51	n
F2	0.5	0.5	3.0	1.6	17
F4	1.1	0.9	0.4	0.0	17
M4	2.7	0.2	0.2	0.8	12

reduction in feeding by adults (Table 5). Feeding of pups was probably underestimated, because pups were probably frequently fed unnoticed away from the den.

Habituating pups to solid food and carrying pups was only observed in F2 (Table 3). Females were observed to chase away pups more frequently than males (74 and 28 fixes, respectively, Chi-square goodness-of-fit = 10.5, d.f. = 1,  $p < 0.001$ ). Playing with pups was observed in F4 and M1, and amounted to 3.2% in M1 (when excluding the period prior to the emergence of pups).

Some foxes frequently entered the den and appeared to be staying inside for prolonged periods. In addition to females that cared for young, this applied to females F1 and F5, and males M5, M6, and to a smaller extent M8. The other males only infrequently entered the den, and did so very briefly probably to look for the pups or the female.

Adult foxes observed at dens were inactive 60–90% of the fixes throughout the pup-rearing period (Table 6). Females and males were not different in their overall activity, with mean  $73 \pm 15\%$  of their time being inactive ( $F = 2.75$ ,  $p > 0.05$ ).

### Social interactions

Interactions between adults were mainly restricted to transfer of food from male to female, or attempts from females to solicit food from the male, and where this happened the two were denoted a pair. Generally, the female was subordinate to the male, but in one pair they seemed to be of equal status. One male behaved submissively towards another male, and the same was observed between two females. Fighting or chasing between adults was never witnessed, but both at den I—81 and II—82 a lot of barking was heard during June. One observation of an apparent agonistic interaction between two adult foxes was made by I. Kirkvoll (pers. comm.) One fox ran towards another, but soon returned to the den where a third fox emerged. Mostly, foxes which were not pairs simply ignored each other.

### Daily activity patterns

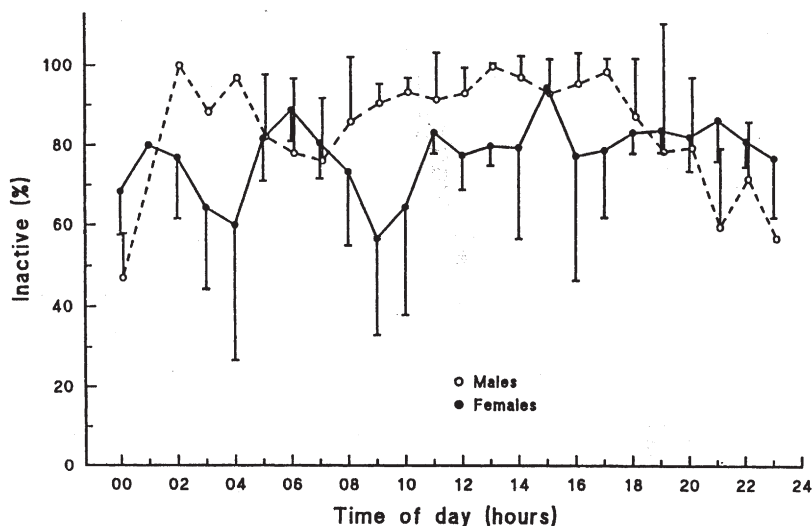
Data on the percentage inactivity was available for 5 foxes throughout most of the day, and for 2 foxes for parts of the day (Fig. 1). Males and females differed in diel patterns (F

Table 6. Percentage of inactivity (lie + sit + stand) of adult Arctic Foxes at dens in southern Scandinavia during different periods. Lines indicate percentage for several periods.

Fox	Prior	Age of pups in days								
		no.	birth	1-20	21-30	31-40	41-50	51-60	61-70	71-80
F1		34.4								
F2			77.7	79.9	56.9	—83.3—				
F3	0.0									
F4			79.1	73.4	73.0	—84.9—				
F5	55.7*									
F6	69.1									
F7					85.8					
M1		97.3	—84.1—							
M2					—73.7—					
M4	98.9		74.2	93.9	87.3	75.0				
M5	57.5*									
M6	83.1									
M7					84.9					
M8					87.3					

\* No pups

Fig. 1. Mean percentage of inactivity (lie + sit + stand) during the day in 7 pup-rearing foxes (females F2, F4, F6 and males M1, M2, M4, M6). Only a single SD is shown for convenience (females = down, males = up).



= 4.86,  $p < 0.05$ ). Male inactivity varied significantly with time of day ( $F = 2.53$ ,  $p < 0.01$ ), as males were most inactive during the middle of the day, but female inactivity did not ( $F = 0.57$ ,  $p > 0.05$ ). Most foxes were more frequently observed during the day than during the night (Table 7, figures in brackets). Foxes at dens were not significantly more inactive during daytime than during nighttime hours (Table 7).

Table 7. Percent of fixes that Arctic Foxes were inactive during the day (08.00—20.00 hours) and night (20.00—08.00 hours) (Wilcoxon  $z = 0.48$ ,  $p > 0.05$ ). The proportion of time (%) that the fox was observed during daytime and nighttime hours is given in brackets.

Fox no.	Day	Night
F2	74.8 (67.6)	77.1 (32.4)
F4	84.1 (64.7)	74.9 (35.3)
F6	67.5 (22.9)	82.5 (77.1)
M1	95.2 (85.1)	72.4 (14.9)
M2	77.8 (66.9)	62.0 (33.1)
M4	94.6 (52.8)	82.5 (47.2)
M5	51.6 (38.8)	76.5 (61.2)
M6	91.2 (54.8)	73.5 (45.2)
Mean±SD	79.6±15.0	75.2±6.5

## DISCUSSION

A flexible social organization in Arctic Foxes at dens was found: a single family, a family with one or two «surplus» foxes, and two families sharing one den. Some «surplus» adults did actually bring food to the den or guard the pups, but they might as well be parents as helpers. The role of «helpers» could not be evaluated because the parentage of pups was unknown, more than one den may be used by a litter, and the uneven distribution of adults' visits to dens throughout the pup-rearing season. Furthermore, it was impossible to evaluate contributions to survival of pups made by adults away from the den, and because some pups left their den at an early age (Frafjord 1984) such contributions could be more important than helping at the den. The frequency of two or more litters in a single den will probably more easily be examined by DNA-fingerprinting methods.

«Helpers» in the Arctic Fox could be expected for two entirely different reasons; (1) To bring a significant amount of food to the den, thus enhancing the survival of the presumably sibling pups in years of low food availability (a case of resource deficiency) or (2) to be allowed to stay in the home range of their parents during periods of high food availability since the cost of this to the reproducing pair is low (a case of resource surplus). «Surplus» adults at dens were observed both in years of low and high abundance of lemmings, so one theory was no more supported than the other.

The very low frequency of contact and ag-

gression among adults is surprising for a canid species; no aggressive encounters between foxes were seen in Scandinavia. Similar observations were made in Alaska (Garrott et al. 1984). In this respect the Arctic Fox seems similar to the Bat-eared Fox *Otocyon megalotis*, which lives in small groups (Malcolm 1986). The insectivorous habits of Bat-eared Foxes and the dispersion of food resources in time and space are probably the factors most important for social organization in this species. The great seasonal and yearly shifts in food availability in the range of the Arctic Fox and a low density of foxes in the study areas could account for a reduced inclination to defend territories and the presence of more than two adult foxes at a den.

In Alaskan Arctic Foxes, Fine (1980) and Garrott et al. (1984) found a significant reduction in the frequency of adults' visits to the den with age of pups, which was attributed to a decrease in the number of visits with food. This decrease may not have resulted in less food given to pups, since pups may have received and consumed an increasing amount of food when away from the den (Garrott et al. 1984). These same trends were generally observed in the present study. In Alaska, females delivered food to the pups more frequently than males. If male feeding of the female prior to the emergence of the pups is excluded, then the results presented here are similar.

Aggression by adults toward pups was restricted to keeping the pups at some distance. As the growing pups became more active and followed adults more frequently, an increase in agonistic interactions could be expected. Females chased away pups more frequently than males, but this resulted from the female spending more time with pups while males more easily retreated away from the den. Tolerant adults may chase away pups more often than intolerant ones, since they stay longer at the den and are frequently harassed by pups.

The activity budgets presented here represent only a part of the foxes' total activity budget because they left their dens when active and could not be observed when far away from dens. Females were mainly resting inside the den until the pups were 3–4 weeks old, and their presence at dens was clearly underestimated during this period. Females that were more frequently observed outside dens during this period may have depleted

their energy reserves, or perhaps their pups had died. The male and female at one den (II—82) were influenced by several visits by two Red Foxes, and one of their pups was killed by a Red Fox (Frafjord et al. 1989). This may explain their higher frequency of presence at the den.

Only minor differences were found between males and females in frequency of bringing food to the den, rate of inactivity, and time spent at the den. Adult foxes visited the den to feed pups and to rest, but since foxes were rarely observed at dens for more than 20% of the day they probably also rested elsewhere or inside the den. Most adult foxes were more frequently observed at dens during the day than during the night, although when present at the den they were not more inactive during the day. In Alaska, adult foxes visited dens more frequently during the night than during the day (Garrott et al. 1984). Pups are more active and more easily counted when adults are present at the den, but time of day does not appear to be crucial for surveys of reproductive success.

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