

Summer food habits of arctic foxes in the alpine region of southern Scandinavia, with a note on sympatric red foxes

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This is a study of the food habits of the arctic fox *Alopex lagopus* by analyzing scats (faeces) collected at seven arctic fox dens in Sylane at the border between Norway and Sweden ($n=518$ scats), and at one den at Finse ($n=100$), both in south Norway. A note on the food habits of the red fox *Vulpes vulpes* in the alpine region (2 dens in Sylane) is also included ($n=60$). Most scats contained only hairs of small rodents and they represent primarily the food of pups. The scats of arctic foxes in Sylane contained on average 73.9% (of occurrence, range 47–87%) lemmings *Lemmus lemmus* and 21.3% voles. At Finse, lemmings constituted 94% and voles 3%. The scats of red foxes contained 10.6% lemmings and 89.5% voles. Other prey species were infrequent both in arctic and red fox scats. Arctic foxes consumed least lemmings at the den of lowest altitude and in years of less abundance of lemmings, but the proportion of lemmings and voles in the field was not known in any year. Consequently, the hypothesis that arctic foxes prefer lemmings and red foxes prefer voles needs further study.

1. Introduction

Arctic and red foxes, *Alopex lagopus* and *Vulpes vulpes*, are opportunistic in their food habits, consuming a variety of available foods (e.g. Hersteinsson & Macdonald 1982). Generally, the diet of the arctic fox is more restricted than that of the red fox, due to fewer prey species in the range of the arctic fox. The two species are sympatric through a large part of the northern tundra region and in the alpine region of Fennoscandia, and are then likely to compete

about food resources (Hersteinsson & Macdonald 1992). The distribution of the red fox may be limited by the productivity of the environment, while red foxes may limit the distribution of arctic foxes (Hersteinsson & Macdonald 1992, see also Frafjord 1993a). In regions where small rodents exist, these are normally included in large proportions in the diet of both fox species (e.g. Englund 1965, Macpherson 1969, Speller 1972, Kaikusalo 1974, Lindström 1980, Garrott et al. 1983, Henry 1986, Fay & Stephenson 1989.). Sympatric arctic and red foxes seem to have a

high dietary overlap (Pedersen 1985, Smits et al. 1989), but no detailed study has been made.

Information on the food of Fennoscandian arctic foxes as well as the food of alpine red foxes is very scanty. In this study I report on the food of arctic foxes in the Sylane and Finse mountains of southern Scandinavia, as revealed by analysis of scats collected at dens. I also include a note on the food of sympatric red foxes in Sylane.

2. Study areas

Sylane is an alpine region along the border of southern Norway and Sweden (about 63°N, 12°E). Some of the characteristics of the region have been described earlier (Cyvin & Frafjord 1988, Frafjord 1988). The highest mountain in the region reaches 1762 m a.s.l., and the tree-line (birch) is at 800–900 m a.s.l. The climate is continental with short cool summers and long, cold winters. At least 5 species of small rodents may be found above the tree-line: *Lemmus lemmus*, *Microtus oeconomus*, *M. agrestis*, *Clethrionomys rufocanus* and *C. glareolus*. In addition to the small rodents, the mammalian fauna above the tree-line is represented by domestic reindeer *Rangifer tarandus*, a few wolverines *Gulo gulo*, arctic and red foxes, hares *Lepus timidus*, stoat *Mustela erminea*, and probably two species of shrews (Soricidae). The above tree-line avian fauna mainly consists of a few passerines (most abundant is *Anthus pratensis*), a few waders and two species of ptarmigan (*Lagopus lagopus* and *L. mutus*).

In Sylane, voles and lemmings were abundant in the summers of 1981 and 1985, low in 1982 and 1983, and increasing in 1984. Except during peak years, lemmings do not normally travel below the tree-line. The most common species of vole in the Norwegian mountains is generally *M. oeconomus* (Hagen 1989).

Finse is situated further southwest than Sylane (60°36'N 7°31'E) at 1100–1700 m a.s.l., and is generally a more barren country than Sylane. The fauna is much the same as in Sylane, but the region is less productive. Small rodents increased in numbers in 1991, and locally reached larger numbers (see also Framstad et al. 1993).

3. Material and methods

In Sylane, faeces (scats) were collected at one arctic fox den in August 1984 and at 7 arctic fox dens and 2 red fox dens in August 1985 (Table 1). Only the most recent scats were collected, being deposited by the last family of foxes to inhabit the den. Because pup scats normally greatly outnumber adult scats at arctic fox dens by the end of the denning season, scats collected at dens are more likely to

reflect the diet of pups than the diet of adults. At den G, both fresh and old scats were collected, probably originating from one litter in 1985 and one in 1981 (Table 1). Den G was probably only used as a secondary den, i.e. pups were born elsewhere (Frafjord 1986, 1992). Thus, pups in den G in 1981 most likely came from den F, and in 1985 from den H. Pups had not been born in the two nearby dens D and E in many years, and the scats collected at these dens may have originated from both juvenile and adult foxes (they were combined). Whether pups recently had lived in the two red fox dens was unknown, but some of the scats collected were small and most likely from pups (den I). The red fox scats collected in 1985 were several years old, and perhaps from 1981 or 1982. Thus, scats collected in Sylane were from a total of 8 arctic fox den-years and from two red fox dens.

At Finse, scats were collected in 1993 and originated from a large arctic fox litter in 1991 and from a small litter in 1992 (none were fresh).

Scats were dried at 60–70°C and individually broken up by hand. Small mammals (voles and lemmings) were identified on the colouration of the hair. Norwegian lemmings *Lemmus lemmus* have a characteristic tricoloured pelage, containing yellow, reddish, and black hairs. Voles have a grey or brown dorsal side and a greyish ventral side, and were not identified to species. Every scat containing small rodent hairs were classified according to whether lemmings could be identified (lemmings) or not (voles). Larger mammals were identified according to a reference hair collection. Single fox hairs were ignored as they most likely originated from grooming. Scats rarely contained any hard items large enough to be identified. Birds were not identified to family because it was possible only in a few cases. The results are given as percent of occurrence (Lockie 1959).

Table 1. Years of scat collection and of the last litters of pups, and the number of scats analyzed at fox dens in Sylane (A–J) and at Finse.

Den	Scats collected	Pups	No. scats analyzed
Arctic fox			
A	1984, 1985	1984, 1985	148, 65
C	1985	1985	82
D	1985	None	1)
E	1985	None	30
F	1985	1981	33
G	1985	1981, 1985	82, 40
H	1985	1985	38
Finse	1993	1991, 1992	100
Red fox			
I	1985	?	37
J	1985	None	23

1) Scats from den D and E were combined

Food remains at arctic fox dens were identified during 1982–1985 when several dens were visited in several years (notably dens A and C). Included was also another den where no scats were collected (den B). The minimum number of individual prey was recorded.

4. Results

The 7 arctic fox dens in Sylane were located at 1027 ± 95 m a.s.l. (mean \pm SD), range 840–1200 m. The distance between the two outermost dens was about 40 km. The distance between the two red fox dens was about 4.5 km and they were located at 770 and 850 m a.s.l., respectively, below and above the tree-line. The shortest distance between one red fox den and one arctic fox den was 7 km.

Most scats contained only hairs of small rodents. Lemmings predominated in scats of arctic foxes and voles in scats of red foxes (Table 2). The range in the occurrence of lemmings consumed at arctic fox dens in Sylane was 47.4–86.6% and (correspondingly) in voles 50.0–8.5%. Den H was the only arctic fox den where the occurrence of voles was higher than the occurrence of lemmings. When this den was excluded the average occurrence of lemmings was 77.6 \pm 6.1%. Den H was positioned at 840 m a.s.l. in shrub habitat, and was the only arctic fox den found below 1000 m a.s.l. The two red fox dens were located at about the same altitude as den H,

but the occurrence of lemmings in scats was only about 11% (Table 2). At the den at Finse (1500 m a.s.l.) lemmings were found in nearly all scats and voles only infrequently (Table 2).

Birds and their eggs had a low percentage of occurrence in scats of both arctic and red foxes (Table 2). Hairs of reindeer were found at only two arctic fox dens in a total of 11 scats (percent of occurrence 5.4 and 3.7, respectively). Berries (*Empetrum hermaphroditum*) were found in 6 scats from den A (4.1% occurrence in scats at this den). The pups at this den were observed to consume berries in august. In 1985, scats from den A contained only lemmings and voles. In 1984, they also contained birds (12.8%) and eggs (2.0%) in addition to reindeer and berries.

A total of 41 food remains were identified at arctic fox dens; 68.3% lemmings, 2.4% voles, 22.0% ptarmigan, and 7.3% unidentified birds. Some reindeer bones were found at most arctic fox dens, but most of them were several years old.

5. Discussion

Most studies on arctic fox summer food habits identify small mammals as the most frequent prey, with lemmings (*Lemmus*, *Dicrostonyx* or *Synaptomys*) occurring in 60–100% of the scats (Table 3). Birds and their eggs, and reindeer (caribou) are next in frequency, and these items are the main prey in regions where small mammals are absent. Only two studies report a higher frequency of voles than lemmings (Table 3).

Some species may be selectively hunted by arctic foxes, i.e. their frequency in scats is higher than their relative numbers in the nature (Garrott et al. 1983, see also Stickney 1991). At present there are no reason to believe that such selective hunting is due to different palatability of the prey species. More likely, some species are more easily caught by foxes than others. Compared to voles, the Norwegian lemming is rather clumsy and slow (and has a more conspicuous colouration), and may possibly spend more time outside their burrows (Andersson 1976, Tast 1982). Furthermore, in peak lemming years Norwegian lemmings may greatly outnumber all vole species (cf. Hagen 1989, Framstad et al. 1993). Conse-

Table 2. Percent of occurrence of food remains in scats collected at arctic and red fox dens in Sylane (mean \pm SD of 8 arctic fox den-years and 2 red fox dens) and at one arctic fox den at Finse.

	Arctic fox			Red fox	
	Finse	mean	SD	mean	SD
Lemmings	94	73.9	12.1	10.6	3.5
Voles	3	21.3	13.8	89.5	3.5
Birds	2	6.6	5.4	3.6	1.2
Eggshell		1.8	3.5	1.4	1.9
Reindeer		1.1	2.2		
Berries		0.5	1.5		
Arctic fox	1				
Sheep	1				
No. of scats	100	518		60	

quently, it is not surprising that lemmings were the most frequent prey of arctic foxes in the mountains of southern Scandinavia. That the arctic fox hunt prey at least partly according to the availability was indicated by the high proportion of voles in scats from the lowest altitude den. The more varied diet at one den (A) in a year of intermediate than in a year of high rodent availability supports this conclusion. Observations at dens also indicated that arctic foxes consumed a high proportion of lemmings (Frafjord 1986), which have been found in high abundance as food remains (Høst 1935). The possible aposematic colouration and distastefulness of the Norwegian lemming (Wallin 1967, Andersson 1976, Taitt 1993) do not prevent predation by arctic foxes. The higher proportion of bird prey in food remains than in scats may be explained by the fact that they produce more waste (feathers and wings) that are more conspicuous and more easy to spot, and that are more lasting than tufts of fur.

The red fox in Sylane also may have been hunting according to the availability of prey. Although the dietary overlap between arctic and red foxes was small in this study, this may reflect different hunting grounds of the two fox species in the surroundings of their dens rather than food preferences. The red foxes may have hunted more below the tree-line where lemmings are scarcer, than above the tree-line. Arctic and red foxes are likely to compete about food resources (Hersteinsson & Macdonald 1992), and a large dietary overlap was found in Alaska (Smits et al. 1989). Still, the hypothesis that the red fox actually has a lower preference for the Norwegian lemming is interesting and should be more thoroughly examined. A feeding experiment by Lund (1962) indicated that farm-bred red foxes preferred voles to lemmings, but only one lemming was used in this experiment. In a study of the food habits of birds of prey in the Norwegian mountains, Hagen (1989) found that lemmings were much less frequently eaten than *Microtus sp.* He (p. 540) sug-

Table 3. Summer food (percent of occurrence, June–August) of arctic foxes estimated from various sources (C=coast, I=inland, as defined by the authors), most of which examined scats collected at dens (S=stomachs). +=frequency 0.1–0.4%. Vegetable matters are excluded.

	Lemmings	Voles	Reindeer	Other terr. mamm.	Sea mamm.	Birds	Eggs	Terr. invertebr.	Marine invertebr.	Fish
North America										
Chesemore 1968	88		15		1	39	36	9		2
Fine 1980	78			4		38		30		
Garrott et al. 1983	94	4	13	18		54	18	19		
Kennedy 1980	61		34	2		3				
Macpherson 1969	74		6	+			13	4		+
Smits et al. 1989	100					7				
Speller 1972	90		+	+		4	2	1		
Bering Sea Islands										
Stephenson 1970 (C)	3	19		2		61	12			
Stephenson 1970 (I)	2	76		7		8	+	2	+	+
West 1987				7	5	38		12	119	7
Murie 1959 (in West)				2	+	59			31	3
Barabash-N. 1938 (S)					7	40		1	94	15
Fennoscandia										
Pulliainen & A.-Kotila 1982	7	28	62	3						
This study	74	21	1			7	2			
Greenland										
Birks & Penford 1990			43	2		15	3	37		1
Iceland										
Hersteinsson 1984 (C)		5			10	78	5	31	18	2
Hersteinsson 1984 (I)			37			70	12	1		
Svalbard										
Frafjord 1993b			+	2	7	112	6			
Prestrud 1992 (S)			49		2	64			8	

gested that lemmings are inferior as food and that voles are preferred by birds of prey.

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