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Food Habits of Arctic Foxes (*Alopex lagopus*) on the Western Coast of Svalbard

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ABSTRACT. Food habits of arctic foxes (*Alopex lagopus*) on the western coast of Svalbard were studied in the years 1986-89. Faeces (n = 1018) were collected mostly in summer, and food remains were recorded both at dens and elsewhere in the region. The foxes were opportunistic in their hunting and feeding habits, utilizing a wide variety of available food items. Alcids (mainly little auks and Brünnich's guillemot), gulls (mainly kittiwakes), and fulmars were the major foods in summer. The consumption of alcids by fox families was correlated with availability near the den. In winter, fulmars and, in one region, seals were important foods. Some regional differences in food consumption were found. A change in diet was observed when a litter of pups moved from one den to another (2 of 3 cases). Differences in food habits between years also were found at the same den (4 of 5 cases). Foxes frequently cached food by scatter hoarding, placing only a single item in each cache.

Key words: arctic fox, *Alopex lagopus*, food habits, prey species, food caching, Svalbard

RÉSUMÉ. On a étudié les habitudes alimentaires du renard arctique (*Alopex lagopus*) sur la côte ouest du Svalbard au cours des années allant de 1986 à 1989. On a recueilli les fèces (n = 1018) surtout en été, et on a consigné les débris de nourriture à la fois dans les terriers et ailleurs dans la région. Les renards se montraient opportunistes dans leurs façons de chasser et de se nourrir, et faisaient usage d'une vaste gamme d'aliments à leur portée. Les alcidés (surtout le petit pingouin et la marmette de Brünnich), les mouettes (surtout la mouette à trois doigts) et les fulmars étaient les sources principales de nourriture estivale. La consommation d'alcidés par les familles de renards était corrélée avec leur disponibilité à proximité du terrier. En hiver, les fulmars et, dans un certain endroit, les phoques constituaient une source importante de nourriture. On a trouvé certaines différences régionales dans la consommation alimentaire. On a observé un changement dans le régime lorsqu'une portée de renardeaux se déplaçait d'un terrier à un autre (dans 2 cas sur 3). On a aussi enregistré des différences dans les habitudes alimentaires d'une année à l'autre au même terrier (dans 4 cas sur 5). Les renards cachaient fréquemment la nourriture en l'éparpillant, ne mettant qu'un élément dans chaque cache.

Mots clés: renard arctique, *Alopex lagopus*, habitudes alimentaires, espèces-proies, cache alimentaire, Svalbard

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INTRODUCTION

Arctic foxes are opportunistic in their feeding habits, preying on lemmings and small mammals where these exist (e.g., Sdobnikov, 1958; Macpherson, 1969; Garrott *et al.*, 1983) and otherwise eating birds and eggs, insects, carrion, or berries (Berns, 1969; Hersteinsson, 1984). Arctic foxes may also kill newborn ringed seal pups (*Phoca hispida*) (Lydersen and Gjertz, 1986; Smith, 1987) or follow polar bears (*Ursus maritimus*) to scavenge carcasses of seals they have killed (Elton, 1949). Refuse from human dwellings may be utilized during winter months (Garrott *et al.*, 1983). Like the red fox (*Vulpes vulpes*), the arctic fox is a generalist, eating a variety of available foods (Ewer, 1973), although its diet may be restricted in comparison with that of the red fox because its geographical range has fewer prey species (Hersteinsson and Macdonald, 1982).

Food caching is an important part of arctic fox food habits. Some authors report that arctic foxes may store a large number of items in the same cache (Murie, 1959, cited in Garrott and Eberhardt, 1987; Pedersen, 1962). Braestrup (1941) stated that they may even "save" these caches until late winter, when other food sources are least available. Little is known of the diet of arctic foxes on Svalbard. Prestrud (1982) analyzed the contents of 62 fox stomachs and found that nearly half of them were empty both in summer and winter and that the rest contained mostly bird remains. The aim of this study is to examine the relative importance of different food items for the arctic fox on the western coast of Svalbard and to compare items eaten to foods available. Additional comparisons between regions, years, and seasons are made, and aspects of food caching behavior are described.

STUDY AREA

About 60% of Spitsbergen is covered by glaciers (Mehlum, 1989). The western part contains a narrow, level plain along the coast, and glaciers and steep mountains are numerous inland. The study areas were on Kongsfjorden (including the peninsula Brøggerhalvøya), Krossfjorden, and Fuglehuken (Fig. 1). Most animal life is found along the coast, but little auks (*Alle alle*) also breed far inland. Several bird cliffs were located in my study areas. The most abundant species were the kittiwake (*Rissa tridactyla*) and the Brünnich's guillemot (*Uria lomvia*) (Table 1). The fulmar (*Fulmarus glacialis*) was also abundant in cliffs, but their numbers were mostly unknown (Mehlum and Fjeld, 1987). Most numerous was the little auk, breeding in colonies of varying size (hundreds or thousands) in mountain slopes. The only terrestrial mammal in addition to arctic foxes was the reindeer (*Rangifer tarandus platyrhynchus*). The numbers and mortality of reindeer on the western coast of Svalbard are low (Øritsland and Alendal, 1986), and the species is protected from human hunting. Polar bears occur only rarely in this region, and most seal carcasses available for foxes originated from human hunters.

Ny-Ålesund is situated on Brøggerhalvøya and is the only human settlement in this region (78°55'N, 11°56'E) (Fig. 1). A number of arctic terns (*Sterna paradisaea*, 500-1000) and common eiders (*Somateria mollissima*, <100) nest in the Ny-Ålesund region. Mean January and July temperatures in Ny-Ålesund for the four years 1986-89 were -14.4 and 4.8 °C respectively. The fjords are normally covered with ice from January to May, but there is a large variation in the amount of sea ice among years, hence in opportunities for foxes to hunt and travel on the ice.

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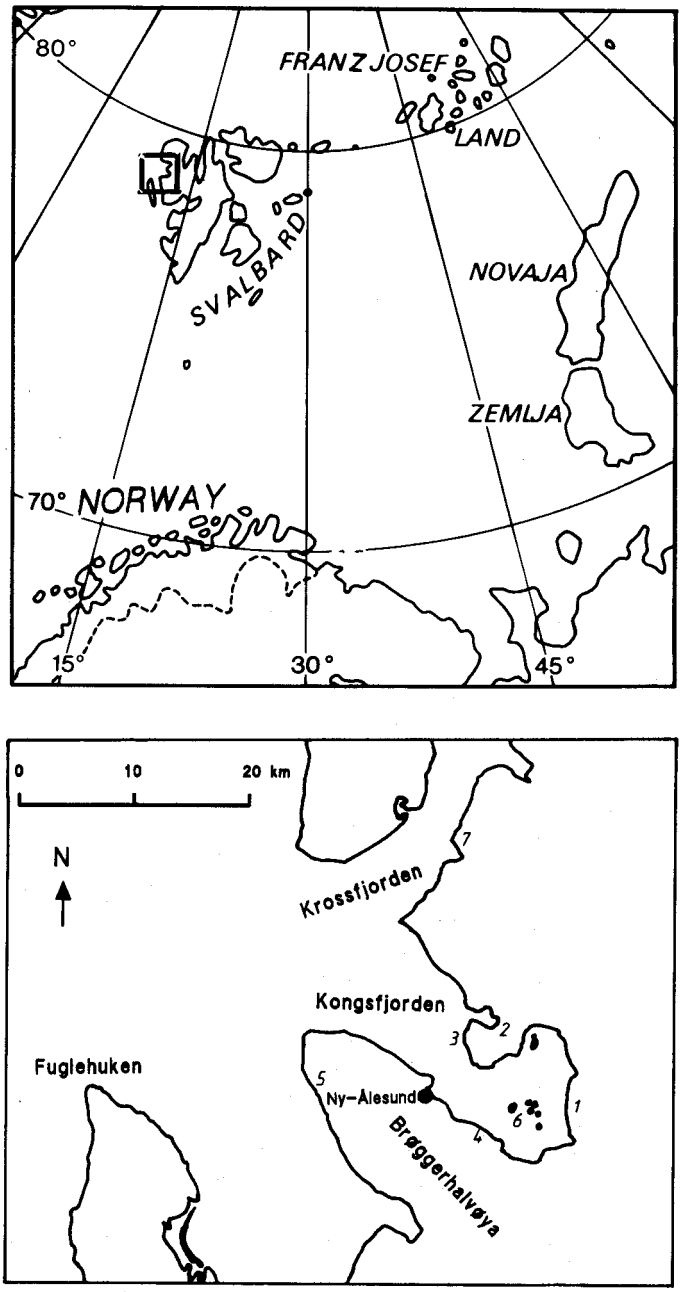

FIG. 1. Map showing the study area on the western coast of Svalbard and the position of dens (numbers).

MATERIALS AND METHODS

I collected faeces (scats) at all fox dens found in the three regions: Kongsfjorden (1986-89, dens 1-6), Krossfjorden (1989, den 7), and Fuglehuken (1986-88, when pups used 4 of 6 dens). Dens were searched for scats at the end of the denning season in the last half of August. Both primary (natal) dens and successive dens used by a litter (secondary dens) were searched. Dens 3 and 4, at which scats were collected in 1986, were not used that year, but according to information available, litters had been observed at both dens in 1985. No attempts were made to distinguish between scats from adults and those from young animals. I also collected fresh scats at dens during the winter and spring. Scats found away from breeding dens were collected in all seasons, of which old scats had probably been deposited in various and unknown seasons.

TABLE 1. Species and numbers (pairs) of sea birds in colonies close to arctic fox dens (partly from Mehlum and Fjeld, 1987)[1]

Den no.	Fulmar	Kittiwake	Brünnich's guillemot	Black guillemot	Puffin	Little auk
1A	–	–	–	–	–	++
1B	–	2 000	500	+	–	–
2	130	1 000	100	20	+	+
3	40	++	–	7	+	+
4	–	600	25	12	–	++
5A	+	–	–	–	+	++
5B	1 000	10	–	+	400	+
6	–	50	–	+	–	–
7	++	3 000	1 500	20	200	++
Fug	440	20 000	30 000	200	500	++

[1] – = not found; + = small numbers; ++ = numerous (hundreds or thousands); Fug = Fuglehuken.

When adequate samples could be found, a minimum of 20 scats from the same area were analyzed. Scats were broken up by hand in water, and feather and hair remains were identified according to Day (1966), Hersteinsson (1984), and a reference collection of known specimens. Only scats containing identifiable bird or mammal remains were included in the analysis. Plant materials were excluded, because no plant species in Svalbard is known to have any important nutritional value to the arctic fox (e.g., berries are very rare in Svalbard). Mosses were found frequently in scats but were assumed to have resulted from accidental ingestion, as pups frequently were digging and biting into the ground during play bouts. Single fox hairs were ignored, as they most likely resulted from grooming.

Prey remains found in the denning areas and away from dens also were identified. Sometimes it was possible to identify prey that was carried by foxes. Food caching behaviour was observed during behavioural studies in Kongsfjorden and Krossfjorden.

Data are presented as frequency of occurrence. I used chi-square goodness of fit statistics to compare frequency of occurrence of individual prey among dens and regions. An index of the difference between dens and regions was calculated according to the equation: $D = (\sum^{n}|a\text{-}b|)/n$, where a = den a, b = den b, n = number of prey groups in a and b. The frequency of occurrence was compared with the relative abundance of the most important prey species by a Spearman's rank correlation (r_s). Prey abundance was categorized according to existing estimates (0 = absent, 1 = 1-500 breeding pairs, 2 = 500-1500 pairs, 3 = >1500 pairs). When such estimates did not exist, categories were assigned according to my own experience of the species' abundance and availability to foxes (*cf.* Table 1).

I compared the relative importance of the various species of bird prey by estimating their caloric value. The numbers of birds eaten were assumed to be equal to their frequency in the scats. Their body weights were taken from Mehlum (1989), and a standard caloric value 1.76 kcal/g wet weight (Hersteinsson, 1984) was assumed. Although these calculations are prone to errors, they weight values to reflect the relative importance of various prey species.

RESULTS

Prey Consumed

All dens were found along the coast (maximum 0.7 km from the sea) and beneath or in the bird cliffs or colonies of little

auks. Fox families were isolated from each other spatially by the sea or by glaciers, or temporally when nearby dens were inhabited in different summers. The exception was on Fuglehuken, where all six dens were found beneath the bird cliffs in a distance of 5 km. In one year at least two litters were found on Fuglehuken.

Alcids formed the major food and were found in more than 50% of the scats, with gulls and fulmars second and third (Table 2). Other foods occurred in percentages less than 5, except eggs and seal. Among alcids, little auks and Brünnich's guillemots were most frequently found in prey remains (Table 3). From Table 3 it was estimated that the numbers of little auks amounted to 74.1% of all alcids in Kongsfjorden, 71.9% in Krossfjorden, and 3.1% on Fuglehuken. The remains of kittiwakes in Kongsfjorden and Brünnich's guillemots on Fuglehuken (Table 3) to some extent originated from the predation by glaucous gulls (*Larus hyperboreus*) and were only partly eaten by foxes.

Alcids and fulmars were most important in terms of relative caloric value (Table 2). The relative importance of little auks, estimated from their frequency in prey remains, was only 8% of the 41% caloric value of alcids, due to their small size. The consumption of alcids was correlated with their abundance in the nearby colonies ($r_s = 0.75$, n = 14, $p < 0.01$), but the consumption of gulls and fulmars was not significantly correlated with their abundance nearby ($r_s = 0.36$ and $r_s = 0.29$ respectively, $p > 0.05$; note: many tied ranks) (Fig. 2).

The average difference (D) between the three main study areas was smaller than between primary and secondary dens, but no significant difference in the D-index was found among the five categories of Table 4 (Kruskal-Wallis 1-way ANOVA: $\chi^2 = 7.89$, d.f. = 4, $p > 0.05$). Regional differences were due to fewer alcids and more fulmars consumed on Fuglehuken than in the other two areas (alcids: $\chi^2 = 8.3$, d.f. = 2, $p < 0.05$; fulmar: $\chi^2 = 64.5$, d.f. = 2, $p < 0.001$) (Table 2). Significant differences among the three areas also were found in the frequency of occurrence of passerines ($\chi^2 = 20.2$, d.f. = 2, $p < 0.001$, mainly snow buntings, *Plectrophenax nivalis*) and seals ($\chi^2 = 10.3$, d.f. = 2, $p < 0.05$). No regional difference was found in the frequency of occurrence of gulls or eggshells ($p > 0.05$). A high frequency of fulmar remains in old scats on Fuglehuken indicated a high importance of this species in the winter diet as fewer of these scats were from the summer (66.1% in scats found away from dens and 20.4% in scats found at dens). In Kongsfjorden, a high frequency of seal hairs was found.

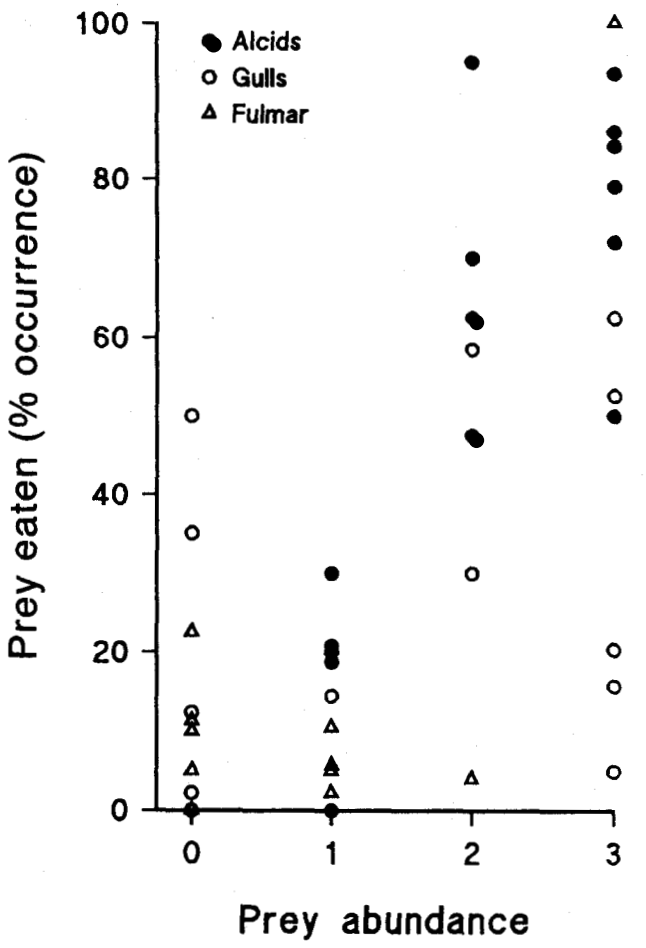

FIG. 2. Relationship between the abundance of alcids, gulls, and fulmar in cliffs nearby dens and their frequency of occurrence in scats (n = 14 fox families). Classification of abundance is described in the method section.

A significant difference between prey remains in scats collected at breeding dens and scats collected away from breeding dens was found for 5 of the 9 prey groups that could be analyzed (Fig. 3). Alcids were more frequently found in the former group than in the latter. A more varied diet was indicated in scats away from breeding dens, where fulmars and seals were more frequent (Fig. 3).

TABLE 2. Frequency of occurrence of prey remains in fox faeces from the three study regions, and estimated percentage of kcal of bird prey[1]

	Kongsfjorden		Krossfjorden		Fuglehuken		Total		Kcal est.
	n	%	n	%	n	%	n	%	%
Alcids	362	55.0+	91	60.3+	88	42.9	541	53.1	41.1
Gulls	170	25.7	33	21.9	50	24.4	253	24.9	15.8
Fulmar	122	18.4	14	9.3	93	45.4+	229	22.5	29.6
Anatids	26	3.9	3	2.0	0		29	2.9	9.7
Ptarmigan	18	2.7	4	2.7	3	1.5	25	2.5	3.4
Passerines	24	3.6	13	8.6+	0		37	3.6	0.1
Waders	18	2.7	1	0.7	5	2.4	24	2.4	0.3
Eggshell	40	6.0	6	4.0	10	4.9	56	5.5	
Seal	60	9.1+	5	3.3	6	2.9	71	7.0	
Reindeer	4	0.6	0		0		4	0.4	
Fox	16	2.4	3	2.0	2	1.0	21	2.1	
No. scats	662		151		205		1018		

[1] + = occurrence higher than expected from the contingency tables.

TABLE 3. Numbers of prey of arctic foxes in three regions on the western coast of Svalbard in the years 1986-89, identified during observations of foxes or by examination of food remains (some of the former may later also have been identified as remains)

Species	Kongsfjorden	Krossfjorden	Fuglehuken	Total
Fulmar *Fulmarus glacialis*	15	8	6	29
Pink-footed goose *Anser brachyrhynchus*	9	3	1	13
Barnacle goose *Branta leucopsis*	2			2
Common eider *Somateria mollissima*	3			3
Ptarmigan *Lagopus mutus*	7			7
Kittiwake *Rissa tridactyla*	137*	25	69	231
Glaucous gull *Larus hyperboreus*		1		1
Arctic tern *Sterna paradisaea*	8	2		10
Brünnich's guillemot *Uria lomvia*	18	13	155*	186
Black guillemot *Cepphus grylle*	6	3		9
Little auk *Alle alle*	83	41	5	129
Puffin *Fratercula nivalis*	5			5
Snow bunting *Plectrophenax nivalis*		1		1
Birds unidentified	54	6		60
Eggs	102**	19		121
Fish	3			3
Sea urchin	8			8
Crustacea	2			2
Reindeer *Rangifer tarandus*	9***			9
Seal	8	2		10
Arctic fox *Alopex lagopus*	3	3	4	10
Bread (human waste)	1			1

*Many probably killed and eaten by glaucous gulls.
**Majority from observations in Ny-Ålesund.
***Probably from only a few dead individuals.

Differences between fox families (litters) were found, even when the distance between their dens was short. For example, dens 2 and 3 in Kongsfjorden were situated only 2.5 km apart, but they differed with respect to gulls and waders ($p<0.05$) but not alcids. The litters in those dens had been born in different years; hence the adults were not restricted by territories and most likely were hunting throughout the whole area, including both dens. No difference in the frequency of occurrence of alcids, gulls, or fulmars was found, however, between the adjacent breeding dens on Fuglehuken. In 4 of 5 cases, a difference between years for the same den was found in at least one prey group ($p<0.05$).

Most litters left their natal or primary den at an age of about one and a half months and often thereafter used one or more secondary dens or den-like structures. When the distance between primary and secondary dens was less than 100 m, no significant differences were found. When the distance between successive dens used by one litter was greater than 100 m, a difference in food habits was found in two of three cases (difference in at least one prey group, $p<0.05$). In one of these cases, the pups shifted their diet from alcids and gulls to almost exclusively fulmars (distance between primary and secondary den about 1 km).

TABLE 4. Average (±SD) of the index of difference (D) of prey remains between categories of scats (sample size [n] is either region, families or single dens)

Category	D	SD	n
Main regions	5.2	2.0	3
Breeding dens v. away from dens	11.2	3.2	3
All families	13.3	2.8	10
Same den in different years	14.7	7.9	5
Primary v. secondary dens	17.9	11.8	3

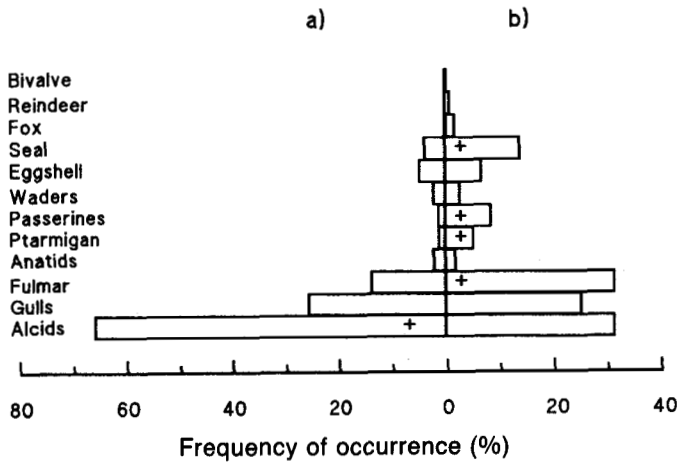

FIG. 3. Frequency of occurrence (%) of food remains from a) fox scats collected at dens with litters of pups (n = 656, excluding den no. 6), and b) scats collected away from breeding dens (n = 328). + = occurrence higher than expected ($p<0.01$).

Den 6 represents an aberrant case, as 53.3% of the scats contained fox hairs and only 20.0% contained alcids. The tiny island on which this den was situated (about 0.12 km^2) is nesting ground for common eiders (anatids 16.7% occurrence in scats), arctic terns, black guillemots (*Cepphus grylle*), and a few pairs of kittiwakes. When the sea ice broke up during the last days of June, the parents were unable to return to the island and attend to their pups, then about one month old. A single pup survived partly by eating his dead litter mates.

Food Caching

The type of caching behavior by foxes was always scatter hoarding. Foxes were never observed to place more than one food item in each cache. The distance between the position where the food was obtained and the position of the cache was studied in Ny-Ålesund (n = 40). Caches were mostly made within 10 m from where the food was obtained (57.5%), some were made 10-20 m away (12.5%), some 20-30 m away (15.0%), and some more than 30 m away (15.0%). A few caches were made as much as 1 km from where the food was obtained. This mostly happened when the fox had finished the night's caches in Ny-Ålesund and was leaving the area. Foxes frequently unearthed a cache, carried it out of Ny-Ålesund, and then reburied it. This may have been done to reduce human interference or to reduce the risk that caches would be located by another fox.

Both adults and pups often cached excess food in the denning area, most of which was soon relocated and eaten or delivered

to pups. Most caches seemed to be eaten during the summer or autumn. In Ny-Ålesund on 24 September 1988, a total of 23 caches had been unearthed by foxes during the previous night (of which 8 had remains of an eider egg, 1 with remains of a tern egg, 2 with remains of a tern chick, 3 with remains of unidentified eggs, and 9 without any remains). On 10 October 1989, a total of 26 unearthed caches were found on two small islands in Kongsfjorden (13 with remains of a tern egg, 2 with goose feathers, and 11 with no remains). Foxes were able to locate the caches through a 70 cm deep layer of snow. The food in a cache usually was covered with only a few cm of soil (rarely as much as 5 cm), so that the foxes managed to dig down to it even when the ground was frozen. In such cases, the foxes merely uncovered the egg, bit a hole in it, and ate it while it was still frozen to the ground. Tracking studies in the winter and spring (573 km) revealed no evidence of foxes uncovering a cache, but some winter faeces contained remains of birds absent in that season. In 40 faeces collected during February-April, the percentage of occurrence of the various groups of prey were: alcids, 32.5%; gulls, 2.5%; fulmars, 32.5%; anatids, 5.0%; ptarmigan, 2.5%; passerines, 5.0%; bird eggs, 7.5%; and seals, 40.0%.

DISCUSSION

Arctic foxes on the west coast of Svalbard are opportunistic in their hunting and feeding habits, as reflected by their diet in relation to the available food in the vicinnity of breeding dens. This conclusion agrees with earlier studies on arctic fox food habits (e.g., Chesemore, 1968; Hersteinsson, 1984). The differences among families could be explained by differences in hunting ranges in the relative abundance of prey species. Differences between years for the same den also may have been due to some specialization or individual differences in the ability to climb the bird cliffs. Some foxes seemed more experienced and proficient in climbing than others. More detailed analysis on the relationship between the abundance of prey species and their occurrence in fox scats could not be performed, because accurate estimates of the numbers of the various prey species and their availability to foxes were mostly not available. The change in food habits within litters could be explained by the family moving to another area where other prey species were more abundant, and also by a change in the frequency of available prey species with time. The guillemots and little auks left their breeding sites by the middle of August, while some of the kittiwake and fulmar chicks stayed in their nests until September.

In summer, the adults, as well as eggs and young, of alcids (mainly little auks and Brünnich's guillemots), gulls (mainly kittiwakes), and fulmars were the most frequent prey. Eggs may have been underestimated as prey of foxes, because only minor amounts of eggshells were ingested. During the winter, fulmars and, in one region, seals were important foods. Foxes were both hunters and scavengers, and they also stole prey from glaucous gulls.

Cannibalism among pups has been noted in Sweden, where starving young ate their dead litter mates (Sklepkovych, 1989). It is noteworthy that one pup managed to survive from the age of about one month without any parents, partly by consuming his dead litter mates and partly by searching for food and caches himself.

Seals seemed to be particularly important to foxes in Kongsfjorden. Many seals were killed by humans during the winter and spring in this region, and this probably accounts for the high frequency of seal hairs in fox scats. Foxes also entered the breeding lairs of ringed seals in spring and killed the newborn pups (*cf.* Lydersen and Gjertz, 1986). A seal carcass may supply a fox with food for many days, although foxes may have to compete with glaucous gulls. The small ringed seal pups (weight at birth about 4.5 kg), however, contain less fat and may be consumed in a day or two.

Some scats collected in winter contained eggshells or feathers of birds absent during that season, and most likely the fox had emptied a cache. Only ptarmigan and occasionally fulmars are found in Svalbard during the winter. This was the only indication that foxes utilized caches during the winter.

Pedersen (1959, 1962) claimed that arctic foxes larder hoard, placing many articles in each cache. He found a larder containing a large number of birds and eggs in Greenland but could not verify that it had been made by a fox, although when found it had been visited by one. In Svalbard, no cache in this study contained more than one item. In Norway, arctic foxes also scatter hoard, but one fox was observed to cache 2-4 items (i.e., a mouthful) in two caches (Frafjord, 1986). The red fox also scatter hoards as a rule (Macdonald, 1976), but on an isolated island in Canada red foxes were apparently larder hoarding (Maccarone and Montevecchi, 1981). Those foxes were thought to be highly dependent on their caches for survival during the winter (Maccarone and Montevecchi, 1981). In Svalbard, most caches seemed to be utilized during the summer and autumn, and the apparent lack of cache utilization during the winter with low prey availability requires further investigation.

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