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Diet of Arctic Foxes (*Alopex lagopus*) in Greenland

CHRISTIAN M. O. KAPEL[1]

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ABSTRACT. The gastrointestinal tracts of 254 arctic foxes (*Alopex lagopus*) trapped or shot in Greenland, mainly during winter, were examined for the presence of food items. The occurrence of different food categories in the gastrointestinal tracts differed significantly between the geographical areas. Overall frequencies of occurrence of food categories were the following: berries (0–67%), seaweed (0–50%), other plant material (6–57%), bird and bird eggs (0–83%), fish (0–31%), shellfish (0–33%), reindeer (0–29%), sheep (0–25%), seal (0–12%), insects (0–10%), larger pieces of muscle tissue (12–57%), human food waste (0–77%), and nonfood garbage (0–50%). In foxes caught near air bases, the gastrointestinal tracts were frequently (53–70%) found to contain human food waste and nonfood garbage. Foxes caught in the more remote districts of Greenland seem less dependent on waste and garbage; they feed on a broad variety of food items according to the local diversity of the prey fauna.

Key words: *Alopex lagopus*, arctic fox, diet, feeding biology, Greenland

RÉSUMÉ. On a examiné le tube digestif de 254 renards arctiques (*Alopex lagopus*) piégés ou abattus au Groenland, surtout durant l'hiver, en vue d'étudier la présence des différents aliments. L'occurrence de diverses catégories de nourriture dans les tubes digestifs variait largement selon les aires géographiques. Dans l'ensemble, la fréquence de l'occurrence des catégories d'aliments était la suivante: baies (0–67 p. cent), algues marines (0–50 p. cent), autres éléments végétaux (6–57 p. cent), oiseaux et oeufs d'oiseaux (0–83 p. cent), poisson (0–31 p. cent), crustacés et coquillages (0–33 p. cent), renne (0–29 p. cent), mouton (0–25 p. cent), phoque (0–12 p. cent), insectes (0–10 p. cent), gros morceaux de tissu musculaire (12–57 p. cent), déchets de cuisine (0–77 p. cent) et déchets non alimentaires (0–50 p. cent). On a trouvé que chez les renards capturés près des bases aériennes, le tube digestif contenait souvent (53–70 p. cent) des déchets de cuisine et des déchets non alimentaires. Les renards capturés dans les régions plus reculées du Groenland semblent moins dépendre des déchets de cuisine et non alimentaires; ils se nourrissent d'une grande variété d'aliments selon la diversité locale de la faune-proie.

Mots clés: *Alopex lagopus*, renard arctique, régime alimentaire, biologie alimentaire, Groenland

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INTRODUCTION

The diet of arctic foxes (*Alopex lagopus*) has been extensively studied (Pedersen, 1931; Braestrup, 1941; Chesemore, 1968; Macpherson, 1969; Kennedy, 1980; Hersteinsson and Macdonald, 1982, 1996; Garrot et al., 1983; Fay and Stephenson, 1989; Prestrud, 1992; Frafjord, 1992). From these studies, it is apparent that the arctic fox is an opportunistic predator and scavenger, but also that most information on arctic fox diet relies on composition of scats collected during summer. In some regions of Greenland, the summer diet of arctic foxes has been evaluated from their scats (Birks and Penford, 1990; Nielsen, 1991) but no studies have been conducted to demonstrate the influence of the different regional prey conditions found in Greenland, and no analyses have been made of gastrointestinal contents. The highly variable prey species availability around Greenland offers an opportunity to study arctic fox populations under a range of prey conditions, i.e., the absence of rodents in West Greenland, the presence of reindeer only in central West Greenland, and the scarcity of other terrestrial mammals in northern West Greenland. The present study investigated the diets of arctic foxes from different zoogeographical regions of Greenland by examining their gastrointestinal contents.

MATERIALS AND METHODS

Gastrointestinal (GI) tracts (stomach, intestine, and colon) were obtained from 254 arctic foxes caught in Greenland by Native hunters in the period 1992–93. The majority of the foxes were caught in traps by Inuit hunters for subsistence purposes; approximately 21 were shot in a government scheme to control fox populations locally. All traps used were spring-loaded killing traps. The bait was fixed in the trap so that the fox could not ingest it. The foxes originated from eight different geographical regions (Fig. 1) and were caught during winter (November-March). Fox carcasses were transported to Denmark and kept

[1] Danish Centre for Experimental Parasitology, Royal Veterinary and Agricultural University, 3 Ridebanevej, DK-1870 Frederiksberg C., Denmark; chk@kvl.dk

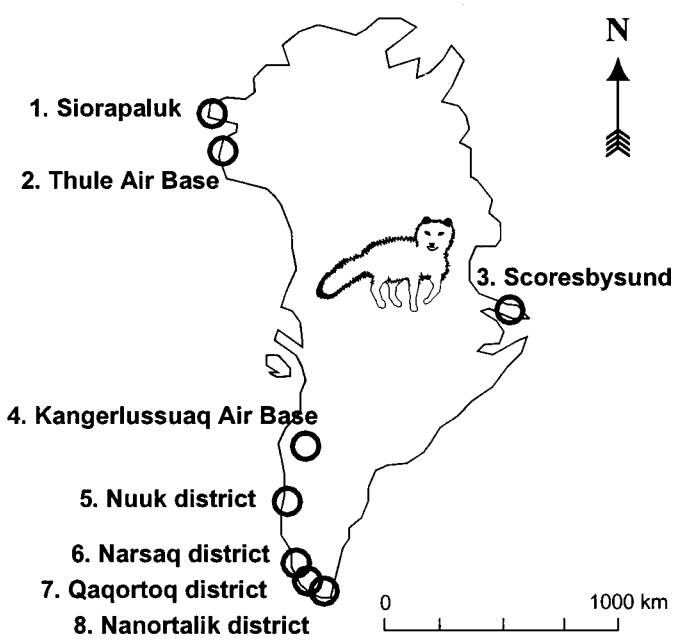

FIG. 1. Sampling areas of arctic foxes (*Alopex lagopus*) in Greenland (60–89°N; 12–73°W).

frozen at -20°C for two to three months prior to necropsy. The contents of the entire gastrointestinal tract were washed in sieves with mesh sizes of 1000 µm and 100 µm. The contents were recorded qualitatively in 12 categories: berries, seaweed, other plant material, birds and eggs, fish, shellfish, larger pieces of undefinable muscle tissue, reindeer, sheep, hare, human food waste, and nonfood material/garbage. Remains of a given animal refer to items that could be identified, such as bones, skin, hair, and feathers; items that could not be so categorized were not recorded. Items were not quantified, but simply recorded as present or absent. Occurrence of food items according to geographical area was analyzed by the Kruskal-Wallis analysis of variance of ranks (Campbell, 1974).

RESULTS

Nineteen (7%) of 254 gastrointestinal tracts examined were empty. The frequency of occurrence of different food categories in the remaining 226 GI tracts is presented in Table 1. The occurrence of food items differed significantly between geographical areas ($H = 19.81$, $\nu = 8$, $p < 0.05$, Kruskal-Wallis test). Most of the human food waste consisted of cooked meat, sausage, bacon, bread, french fries, salad, raisins, and corn. Nonfood garbage consisted mainly of pieces of plastic, paper, clothes, and rope. No identifiable remains of collared lemming (*Dicrostonyx torquatus groenlandicus*) were found in Scoresbysund (Area 3), the only one of the eight study areas where lemmings are distributed. Nor were any remains of muskox (*Ovibos moschatus*) found, even though a large muskox population is located around Kangerlussuaq Air Base (Area 4). Soil and fox hair were present in the majority of the GI tracts.

Empty stomachs appeared to be more frequent among foxes less than one year old, but this tendency was not significant ($p > 0.05$, χ^2-test).

DISCUSSION

Analysis of gastrointestinal contents, as used in this study, is probably more accurate than observations of feeding behaviour and analysis of scats. The method registers the contents of the stomach in addition to items in the intestine that have been partially digested. Therefore, easily digestible items are more often detected in the gastrointestinal contents than through analysis of scats. However, this study has some limitations: the majority of the foxes were caught during winter, and the proportional volume of the various items was not determined.

Both the diversity of the food items found in their scats and stomachs and observations of their feeding behaviour demonstrate that arctic foxes are truly opportunistic and generalistic feeders, adapting quickly to changes in food availability (Chesemore, 1968; Macpherson, 1969; Kennedy, 1980; Hersteinsson and Macdonald, 1982, 1996; Garrot et al., 1983; Fay and Stephenson, 1989; Birks and Penford, 1990; Nielsen, 1991; Prestrud, 1992; Frafjord, 1992). They prey on the most abundant animals, scavenge carrion and garbage, and appear to ingest almost everything. For example, during the field period of this study, pieces of a glove reappeared in the stomachs of three foxes caught the day after the glove was lost.

Eberhardt et al. (1982) and Garrot et al. (1983) suggested that garbage dumps in areas with high human activity may provide enough food to sustain larger arctic fox populations than would otherwise be found. The high occurrence of garbage and human food waste found in foxes at the northern (77°N) Thule Air Base (Area 2) and at the southern (67°N) Kangerlussuaq Air Base (Area 4a) support this assumption. The prey fauna of the latter area is relatively more diverse and numerous, and therefore foxes in this area may depend less on waste from human activity. Generally, foxes caught in the more remote regions of Greenland (Areas 1, 3, 4b–8) appear to depend less on waste and garbage; their diet reflects the local diversity of the prey fauna.

Remains of reindeer (*Rangifer tarandus*) were not found in the northern areas, but they were found frequently in foxes near Kangerlussuaq Air Base (Area 4b; 29%) and settlements in the Nuuk community (Area 5; 15%). These areas are known to have the largest populations of reindeer in Greenland (Meldgaard, 1986). Analysis of fox scats from the same region revealed that remains of reindeer were present in 96% of the scats in May, but their frequency declined to 27% in August (Birks and Penford, 1990). Thus, foxes in Greenland appear to scavenge more intensively on reindeer carrion in spring than during the rest of the year. Similarly, in Svalbard Prestrud (1992)

TABLE 1. Frequency of occurrence of food items found in gastrointestinal tracts of arctic foxes (*Alopex lagopus*) from Greenland.

Area	No. of GI-tracts examined	No. of empty GI tracts	Berries	Seaweed	Other plant material	Bird/egg	Fish	Shellfish	Large muscle tissue pieces	Reindeer	Sheep	Hare	Seal	Insects	Human food waste	Non-food garbage
1 Siorapaluk	19	4	0	0	13	80	0	0	13	n.a.[1]	n.a.	20	7	0	0	0
2 Thule Air Base	96	4	3	0	12	14	1	0	12	n.a.	n.a.	0	0	0	77	50
3 Scoresbysund	17	0	0	0	6	24	24	0	59	0	n.a.	0	12	0	0	41
4a Kangerlussuaq Air Base	43	2	2	2	23	21	0	0	12	12	n.a.	0	0	0	58	26
4b Kangerlussuaq surround	7	1	29	0	57	43	0	0	57	29	n.a.	0	0	0	0	0
5 Nuuk district	33	7	27	4	15	35	31	27	42	15	0	4	0	0	8	35
6 Narsaq district	12	0	17	25	8	0	17	33	17	17	25	8	0	0	8	8
7 Qaqortoq district	21	1	5	5	20	20	10	15	40	5	20	10	0	10	0	0
8 Nanortalik district	6	0	67	50	50	83	17	0	17	0	0	0	0	0	0	0
Total	254	19														

[1] n.a. = food item not available in the area

found remains of reindeer in 42% of the fox stomachs during winter but in only 23% during summer. These findings may be explained by higher availability of reindeer carrion at the end of the winter period or higher mortality of calves just after the calving period. In northern Canada, Macpherson (1969) found that caribou bones in arctic fox scats most frequently were from calves. The occurrence of reindeer in foxes from the southernmost areas (Areas 6 and 7) can only be explained by the presence of reindeer farms, as free-ranging or wild populations of reindeer are usually not found in these areas.

Remains of sheep (*Ovis aries*) were found only in foxes from the southernmost areas, to which sheep farming is restricted. Sheep are kept indoors during winter; hence, scavenging on carcasses may account for the remains of sheep found in the foxes in this study. Sheep carcasses may be available to the foxes in the form of dead sheep left in the mountains, as newborn lambs killed earlier by predators, or as offal from home slaughtering.

Even though the arctic hare (*Lepus timidus*) is found in all parts of Greenland, it appears to be of minor importance in the diet of arctic foxes in most areas. The relatively high occurrence of hare in the northernmost settlement (Area 1) may be attributed to the fact that it is the only terrestrial mammal present. Farther south, Birks and Penford (1990) found remains of hare in only 2% of fox scats collected during late spring and summer in central West Greenland. Similarly, remains of hare were found in only 1% of arctic fox scats collected in northern Canada (Macpherson, 1969).

Seal remains were found in low frequencies (7% and 12%) in foxes from Areas 1 and 3, where seals are intensively hunted. In contrast, seals appear to be of negligible importance in the coastal areas of southern Greenland. Arctic foxes are known to scavenge on remains of seals killed by polar bears (*Ursus maritimus*) (Stirling and Smith, 1977), but foxes are also capable of killing seal pups themselves (Smith, 1976; Lydersen and Gjertz, 1986). In Svalbard, the occurrence of seal remains in scats (Frafjord, 1992) and stomach contents (Prestrud, 1992) of the arctic fox shows seasonal and geographical differences ranging from 0% to 22%. The highest occurrence was found in coastal areas during winter.

The source of large pieces of muscle tissue in the present study differs by area. At the air bases (Areas 2 and 4a), the muscle tissue is likely to be uncooked meat waste from canteens. In the northern settlements (Areas 1 and 3), polar bears, walrus (*Odobenus rosmarus*), seals, and whales are traditionally hunted, providing a source of muscle tissue. Large populations of muskox and reindeer are found in the inland areas surrounding Kangerlussuaq Air Base (Area 4b), and could be sources of meat for the foxes here. In southernmost Greenland (Areas 6–8), farmed sheep are the most likely source. Because it is difficult to determine the origin of this muscle tissue, some prey species might be missing in Table 1 (polar bear, muskox, walrus, and whales were not recorded in any area), and others might be regionally underrepresented (since reindeer, seals, and sheep are found in some areas). The muscle tissue is likely to be remains of Inuit hunting, but could also originate from prey killed by large carnivores. As such top predators, polar bears might be important in the coastal areas of North Greenland and white-tailed sea eagles (*Halientus albicilla*) in southern parts of West Greenland. Wolves (*Canis lupus*) have reappeared in low numbers only in Northeast Greenland, but no foxes from that area were collected in this study.

Remains of birds and birds eggs were found in foxes from most of the areas, but with varying frequencies (0–80%). Birks and Penford (1990) found bird remains in 3% of fox scats during spring and in 47% in late summer. Similarly, the occurrence of bird remains in the stomachs of arctic foxes from Svalbard varied (from 4% to 45%) depending on season and geographical area (Prestrud, 1992). In the present study, foxes from Siorapaluk (Area 1), located near one of the world's largest colonies of little auk (*Alle alle*), appear to specialize, feeding on this bird and its eggs. The findings of both Birks and Penford (1990) and Prestrud (1992) indicate that the importance of birds in the diet of the arctic fox is highly dependent on the local availability of birds.

Especially in the coastal areas of central and south Greenland, fish, shellfish, and seaweed are important food sources for the fox. Accordingly, Fay and Stephenson

(1989) found that marine invertebrates and seaweed often occur in stomachs of foxes living in coastal areas. It is known that arctic foxes scavenge in the tidal zone (Vibe, 1950), but foxes have also been observed to catch fish alive (Nielsen, 1991). Birks and Penford (1990) observed bones from arctic char (*Salvelinus alpinus*) in 6% of the fox scats collected in June in inland areas of central West Greenland. In the present study, remains of fish were not found in the same areas (4a and 4b) that Birks and Penford (1990) studied, presumably because the foxes were caught during winter, when lakes and streams are frozen. Wastes from intensive marine fisheries located nearby might explain the frequent occurrence of fish fragments in Areas 3 and 5.

Pupae of insects were found only in a few foxes from southern Greenland (Area 7). Birks and Penford (1990) found insects in 58% of arctic fox scats collected in central West Greenland during summer; moth pupae were most frequent. Macpherson (1969) found a high occurrence of large bees (*Megabombus* sp.) in scats from some foxes but not from others, and suggested a selective hunt for insects, either by digging them out or by lying in wait at their nests. No insects were found in studies on scats and stomach contents of foxes from St. Lawrence Island, Bering Sea, (Fay and Stephenson, 1989) and Svalbard (Prestrud, 1992). Thus, apart from the High Arctic areas, insects may be regarded as a potential source of food for the arctic fox in Greenland.

Berries and other plant material were found in foxes from both northern (0–3%) and southern (5–67%) areas. This fact suggests that during winter, foxes eat berries that were frozen during autumn and preserved under the snow. During summer, berries might account for a larger proportion of the diet, especially in the southern areas of Greenland. Unfortunately, plant material was not included as a food category the study by Birks and Penford (1990) on the summer diet of arctic foxes in Greenland. In Svalbard, which is further north, Prestrud (1992) found plant material in 5% of the foxes both during summer and winter. In the Keewatin district of Canada, at latitudes similar to those of southern Greenland, berries were found in 1–12% of the scats; their occurrence was highly variable from year to year and from month to month, with the highest occurrence found in summer (Macpherson, 1969).

Collared lemmings have never existed in western Greenland, but surprisingly, no remains were found in foxes from Scoresbysund, East Greenland (Area 3), where lemmings are present. The only explanation can be that the highly fluctuating lemming populations might have been at a minimum. Unfortunately, no information is available on lemming populations from this area during the period when the foxes were collected. In northern Canada, where lemmings are abundant, remains were found in the stomachs of most foxes (up to 90%) (Macpherson, 1969).

From this study on gastrointestinal contents, it is obvious that the diet of arctic foxes in Greenland shows geographical differences according to the diversity of the prey fauna. The local differences in diet support the finding by others that arctic foxes are opportunistic and generalistic feeders, and that diversity and availability of prey fauna determine what is actually ingested. The availability of human food waste greatly influences the diet of the foxes, and carcasses and offal from hunters, fishermen, and farmers are likely to influence the diet in the same way. Studies on the diet of foxes in the tundra areas on east Greenland are still needed to determine the importance of lemmings during minima and maxima of lemming populations.

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