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THE OCCURRENCE OF RABIES IN THE SVALBARD ISLANDS OF NORWAY

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ABSTRACT: After the first recorded outbreak of rabies in the Svalbard Islands (Norway) in 1980, brain tissue from 817 trapped arctic foxes (*Alopex lagopus*) was tested for rabies by a direct fluorescent antibody test. During the same period (1980 to 1990), 29 arctic foxes, 23 polar bears (*Ursus maritimus*), 19 reindeer (*Rangifer tarandus*) and five ringed seals (*Phoca hispida*) were also tested using the same technique. These animals had either been found dead, killed because of abnormal behavior or were apparently healthy when they were collected. Rabies virus antigen was not detected in any of the trapped foxes. Rabies was confirmed in two foxes in 1981, two foxes and one reindeer in 1987, and in one fox in 1990. The presence of rabies in the Svalbard archipelago probably resulted from immigration over the sea ice of an infected host.

Key words: Rabies, arctic fox, *Alopex lagopus*, survey, direct fluorescent antibody test.

INTRODUCTION

Rabies appears to be endemic throughout the Arctic region, and several epizootics have been documented the last 30–40 years (Rausch, 1958; Kantorovich, 1964; Syuzyumova, 1968; Crandell, 1975; Ritter, 1981; Holck, 1989). The arctic fox (*Alopex lagopus*) is the main vector of rabies in the Arctic, but other mammals may also be infected (Rausch, 1958; Ritter, 1981; Ødegaard and Krogsrud, 1981).

The infection was detected in the Svalbard islands in the European high Arctic for the first time in 1980 (Ødegaard and Krogsrud, 1981). By use of a special monoclonal antibody, rabies virus from Svalbard, together with arctic fox strains from the USSR, Greenland and Alaska, could be differentiated from other strains of Lyssavirus 1 (Schneider et al., 1985). Recent outbreaks of rabies in Finland and subarctic regions of the USSR were also caused by a virus with this epitope (Westerling, 1989; Selimov et al., 1990). Rabies in the Arctic has also been demonstrated to be a progenitor of enzootics in subarctic Canada (Tabel et al., 1974).

Carey (1985) pointed out that a major deficiency in studies of rabies in wildlife has been the failure to investigate rabies by systematically collecting animals from areas where the disease is enzootic. Few such studies have been conducted in the Arctic, where the prevalence of rabies in trapped arctic foxes has been reported to be between 0.7% and 75% (Kantorovich, 1964; Syuzyumova, 1968; BEAK consultants, 1975; Secord et al., 1980).

The present investigation on possible rabies virus infection in trapped arctic foxes was conducted to evaluate the significance of rabies in Svalbard from 1980 to 1989. In addition, foxes and other mammals found dead or killed because of abnormal behavior during 1980 to 1990 also were tested for rabies virus.

MATERIALS AND METHODS

Arctic foxes were collected from seven different locations on Spitsbergen, the largest island in the Svalbard archipelago (74° to 80°N, 10° to 30°E) (Fig. 1).

During the years 1980 to 1981 and 1983 to 1989, 817 carcasses were collected from 12 professional and recreational trappers, and as part of a population study of the arctic fox. Seven-hundred and ninety-three of these foxes were caught in baited Spitsbergen-traps (trapdoor with a heavy load of stones, killing the fox immediately, baited with ptarmigan, sea birds or reindeer) and 24 were shot. The trapping season was between November 1 and March 15, and the numbers of sampled foxes each year (July 1 to June 30) were 75 in 1980–81, 68 in 1983–84, 112 in 1984–85, 185 in 1985–86, 136 in 1986–87, 153 in 1987–88, and 88 in 1988–89. Foxes were collected from seven different areas, and the location was known for 742 (see Fig. 1 for location of areas) including 366 in area 1, 121 in area 2, 121 in area 3, 17 in area 4, 10 in area

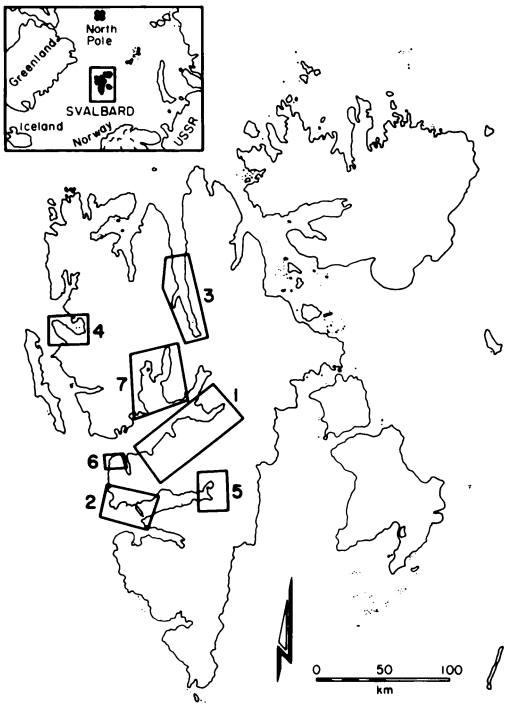

FIGURE 1. Svalbard archipelago with the different trapping-area. Numbers refer to trapping areas in the text.

5, 8 in area 6, and 99 in area 7. Fox heads and, in a few cases, just the brains, were stored frozen at −18 C to −25 C for 0 to 40 mo prior to examination for rabies.

Between autumn 1980 and spring 1990, another 29 arctic foxes, 23 polar bears (*Ursus maritimus*), 19 reindeer (*Rangifer tarandus*) five ringed seal (*Phoca hispida*), two dogs and one cat were examined for rabies. Most of these animals were found dead, but some were killed because they were behaving abnormally, and some were apparently healthy when they were shot. Nineteen of the polar bears were shot after attacking people. Two of the seals were submitted for examination because they exhibited paralysis of the hind quarters. Heads of animals other than foxes, and carcasses of shot foxes, were stored frozen at −18 C to −25 C for up to 2 mo before being examined for rabies.

The brains were examined for rabies virus by a standard fluorescent antibody test (FAT) (Dean and Abelseth, 1973). Anti-rabies virus nucleocapsid conjungate from the Pasteur Institute, (Paris, France) was used.

The lower canine teeth were removed for age determination in 734 of the 817 foxes collected from trappers and from two of the foxes shot because of aggressive behavior. Age was determined by counting the incremental lines in the cementum after sectioning and staining the teeth (Grue and Jensen, 1976) (Table 1). The sex of these animals was recorded.

Fifty trappers' diaries from the period 1895 to 1940, stored at the Norwegian Polar Research Institute's (Oslo, Norway) library, and seven trappers' accounts from the period 1930 to 1960 were carefully searched for mention of incidents of aggressive arctic foxes, abnormal mortality among arctic foxes, and diseases among sled dogs.

RESULTS

Rabies was not demonstrated in any of the 817 foxes collected from the trappers and in connection with a study of arctic fox population dynamics. In the period from autumn 1980 to autumn 1990, five foxes (one in autumn 1980, one in 1981, two in 1987 and one in 1990), and one reindeer (1987), were diagnosed as rabid. The two foxes shot in 1987 were 3- and 5-yr-old. Three of the foxes and the reindeer were shot because they behaved aggressively or otherwise abnormally, one fox was killed by a dog and one was found dead. These foxes were killed in December to May, and the reindeer was shot in July. Rabies was not confirmed in any of the other animals examined. No conclusive indication of incidents of rabies was found in any of the trappers' diaries or accounts.

DISCUSSION

In areas where rabies has been studied thoroughly, the recorded prevalence seems to fluctuate considerably. Characteristically, there is a high number of cases in wildlife for a 1 to 3 yr period, alternating with 3 to 6 yr periods when rabies is uncommon before increasing again (Macdonald, 1980; Macdonald and Voigt, 1985; MacInnes, 1987). However, such fluctuations of rabies in arctic foxes have not been documented. There are too few data to permit final conclusions, but the observed pattern of rabies cases in Svalbard since 1980 indicates the occurrence of the disease there fluctuates, and is now enzootic in the archipelago. Thus, outbreaks can be expected in the future.

TABLE 1. Age and sex composition of foxes sampled for rabies.

Age Years	Sex[a]	
	M[b]	F[b]
0	220	188
1	62	45
2	34	34
3	22	19
4	16	16
5	10	10
6	8	10
7	9	10
8	4	8
9	3	4
10	1	1
Total	389	345

[a] There were an additional 83 foxes of unknown age and sex, making an overall total of 817.
[b] M, male; F, female.

Despite the fact that rabies was confirmed in arctic foxes in Svalbard in the period 1980 to 1989, the virus was not detected in any of the trapped foxes. In several comparable studies, the rabies virus was detected in some, but not in all, arctic fox populations during epizootic and inter-epizootic periods (Table 2). For example, rabies virus was not found in 320 foxes from three different locations in the Canadian Arctic (Secord et al., 1980), even though 18 cases of rabies had been reported from this area during the 10 yr prior to the investigation.

The prevalence of rabies in trapped vector species during epizootics is commonly 1 to 5% (see Wood and Davies, 1959; Verts and Storm, 1966; Steck and Wandeler, 1980; Carey, 1985). Thus, the occurrence of rabies during epizootics seems to be higher in trapped arctic foxes (9 to 75 %) (Table 2) than what is common in other trapped vector species. Given that the average prevalence of rabies in the fox population in Svalbard was $\leq 1\%$ in the period 1980 to 1989, and that the trapped material is a representative sample of the fox population, the probability (P) of detecting no positive cases out of 817 trapped foxes is $P \geq 0.0003$ (binomial distribution). Consequently, it is likely that the average prevalence of rabies in the fox population in Svalbard in this period was much lower than 1%. However, systematic sampling of trapped foxes as we have done may underestimate the prevalence of rabies because sick foxes may be less likely to be trapped.

Of the other mammals examined, only one reindeer had rabies. Rabies has been

TABLE 2. Prevalence of rabies virus in samples of foxes trapped in different areas during period when epizootics of rabies were and were not observed.

Area	% Positive	n	Yr	References
Siberia				
Yamal	8.8	79	1958–59[a]	Syuzyumova (1968)
	0.7	402	1960–61[b]	Syuzyumova (1968)
	10.0	426	1961–62[a]	Syuzyumova (1968)
Nenets region	3–75	1,390	1954–62[a,b]	Kantorovich (1964)
Canada				
Banks Island	21.9	201	1977–78[c]	Secord et al. (1980)
	5.4	258	1973–74[c]	BEAK consultants (1975)
Cambridge bay	0	127	1977–78[c]	Secord et al. (1980)
Gjoa Haven	0	100	1977–78[c]	Secord et al. (1980)
Spence Bay	0	93	1977–78[c]	Secord et al. (1980)
Alaska	9	56	1956[a]	Rausch (1958)
	37	59	1977[a]	Ritter (1981)

[a] Years of epizootic.
[b] Years between epizootics.
[c] Epizootic status not known.

observed in several other arctic mammals earlier (Tabel et al., 1974; Ritter, 1981; Ødegaard and Krogsrud, 1981; Holck, 1989; Taylor et al., 1991).

In a sparsely populated arctic area such as Svalbard (approximately 0.05 humans/km^2), the probability of detecting rabid animals is low. About 80% of all detected rabies cases in the island were less than 20 km from the permanent settlements. The low overall mean frequency of reported rabies cases in Svalbard (0.00003 cases/km^2/year) compared to well studied enzootics, i.e., Ontario, Canada (highest report 0.017 rabid foxes/km^2/year) (MacInnes, 1987) and West Germany (0.019 cases/km^2/year) (Jackson and Schneider, 1984), probably reflects both the much lower densities of humans to detect dead or sick animals, and animals susceptible to rabies, in Svalbard than in Ontario and West Germany. Ecological differences may also be of importance.

Alternatively, two factors may increase the chance of detecting rabid mammals in Svalbard despite the low human population density. There is no vegetation to cover dead or dying animals, and people travel extensively outside the settled areas with oversnow machines, boats and aircraft throughout the year. The eight permanent settlements, and four to six permanently settled trappers, are spread out over large parts of Svalbard. The awareness of rabies is high among the residents because of attention paid to the outbreak in 1980 and to the information campaigns designed to help keep Scandinavia free of rabies. In addition, most people in Svalbard carry firearms for protection against polar bears, so they could, and probably would, kill animals showing abnormal behavior. Consequently, we conclude that the reported cases are fairly representative of the frequency of occurrence of rabies in Svalbard.

According to several studies (Elton, 1931; Rausch, 1958; Kantorovich, 1964; Syuzyumova, 1968; Crandell, 1975), rabies in arctic foxes is seasonal in character, mainly observed during November to April, and with most cases occurring in February to April. The records of rabies cases in Svalbard are fairly consistent with this chronology.

Both Syuzyumova (1968) and Secord et al. (1980) showed that the prevalence of rabies in arctic foxes can differ between areas close to each other. The samples from Svalbard were collected from several different trapping-areas (Fig. 1), and 60% were collected in areas where 80% of rabies-positive foxes had been detected. Furthermore, the sample had a varied age and sex composition (Table 1). These data suggest that the absence of detectable rabies in trapped foxes cannot be explained by lack of sampling of particular age or sex classes, or by sampling from only one restricted area.

Although the FAT is of high sensitivity, Taylor et al. (1991) reported that it failed to diagnose rabies in a polar bear. However, the chance of missing positive specimens seems low since there were no difference between FAT and the mouse inoculation test used on arctic fox brains (Secord et al., 1980), and numerous studies have shown that FAT in general is reliable if performed correctly (e.g., Zimmer et al., 1990).

A rabies-like disease referred to as "Arctic dog disease" was well known in the Arctic region before the rabies virus was confirmed in 1947 (Elton, 1931; Rausch, 1958; Kantorovich, 1964). In a single year the disease could kill more than 50% of the sled dogs. Nothing similar is known from Svalbard, even though trapping was quite common (10 to 30 trappers each year) before 1941. Since these trappers were literate and acutely interested in natural phenomena, we feel confident that a serious epizootic disease would have been reported had it occurred. After observing a rabies-like disease in his sled dogs, Lønø (1966) sent a questionnaire to several trappers in Svalbard and eastern Greenland, but only one of the replies mentioned a case of an arctic fox showing rabies-like

behavior. There are also a few verbal reports from the 1970's of aggressive foxes and an unknown disease among dogs being put to death. It is impossible to unequivocally confirm the first occurrence of rabies in Svalbard, but the available reports give no evidence of outbreaks before 1980. Taken together we feel that the documented occurrence of rabies in Svalbard in the 1980's, and the lack of reliable reports on an epizootic disease from trappers and scientists with long experience from field work in the archipelago, indicate that rabies most likely was not present there in this century before 1980.

The most likely origin of rabies in Svalbard is via immigration over the sea ice of arctic foxes from Greenland or the Siberian islands. Rabies was reported in western Siberia over 25 years ago (1,300–1,400 km from Svalbard) (Kantorovich, 1964, Syuzyumova, 1968), and is still present here (Selimov et al., 1990), but details are lacking. Rabies has been endemic for several years in western Greenland and was also detected in eastern Greenland 15 yr ago, and recently (1989) in northeast Greenland only 600 km from Svalbard (Holck, 1990). Arctic foxes are known to travel long distances (up to 2,300 km), and they have been observed far out on the drift-ice (Eberhardt and Hanson, 1978; Garrott and Eberhardt, 1987). Although immigrations of arctic foxes into the Svalbard area have not been described, the islands are in contact with pack ice in all months but August and September. Thus, it is also possible that rabies was absent from Svalbard in the 1980's when the infection was not recorded, and that it has been reintroduced by migrating foxes.

The epizootiology of rabies in wildlife cannot be understood without understanding the ecology of the vector species (Macdonald, 1980; Macdonald and Voigt, 1985). Several authors have linked the outbreak of rabies among arctic foxes to peaks in the population density (Elton, 1931; Kantorovich, 1964; Syuzyumova, 1968; Ritter, 1981), but no systematic studies have been conducted to test the hypothesis. In most areas arctic fox numbers fluctuate in conjunction with cycles in small mammal abundance (Elton, 1931; Macpherson, 1969). However, in Svalbard, there are no small mammals (except for some voles in the human settlements accidentally introduced by ships), and the arctic fox mainly feeds on reindeer and seal carcasses, ptarmigans (*Lagopus mutus*), sea birds and waterfowls (unpubl. material). It is not known whether the arctic fox population in Svalbard fluctuates or not. In some years, food availability increases greatly due to high reindeer mortality following ice cover on the vegetation, which might stimulate increased reproduction of arctic foxes, but this hypothesis has not been tested. These ecological differences may influence the way rabies is retained and spread in wildlife in Svalbard.

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