HISTORY AND EPIZOOTIOLOGY OF RABIES IN CANADA

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Introduction

THERE IS EVIDENCE THAT RABIES existed in vampire bats in Central America before the discovery of the western hemisphere by Columbus. Constantine (7), qouting De Oviedo y Valdes (1526), states that "many of the conquering troops and their lifestock perished with rabies-like symptoms following bites by vampires. Natives were accustomed to avoiding the disease by washing the wound and cauterizing it with wood embers."

Many cases of rabies have been reported in man, domestic animals and wildlife in the United States during the last century (15).

The purpose of this paper is to document the history and epizootiology of the disease in Canada.

Early History

The question of how long rabies has been present in Canada remains unanswered. The first recorded case of rabies in Canada was observed near Ottawa, Ont. in 1819. The Duke of Richmond, who was Governor-in-Chief of Canada at the time, is said to have died of hydrophobia while on a journey from Kingston to Quebec City. The source of infection remains controversial. Presumably, the Duke had been exposed to rabies either by an aggressive pet fox or by his pet dog "Blucher" (14, 21). A cairn erected near the village of Richmond, Ontario where the Duke died, commemorates this tragic event (Figure 1).

The only other recorded case of rabies in Canada during the 19th century was described by a physician from Quebec City in 1839. A patient of his died with symptoms typical of rabies six weeks after he had been bitten in the face by a rabid dog (21).

These two accounts indicate that rabies occurred in Canada in dogs and possibly wildlife 150 years ago. Since 1867, the "Report of the Minister of Agriculture for the Dominion of Canada", issued annually, included information of various infectious diseases diagnosed in domestic animals. From 1866 to 1900, rabies was not mentioned in these reports.

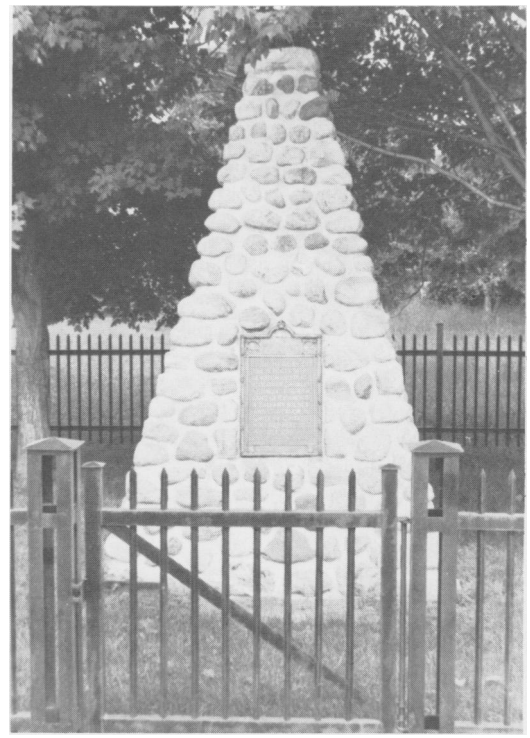

FIGURE 1. Cairn near Richmond, Ontario. Memorial to the Governor-in-Chief of Canada who died of rabies.

1900 to 1945[1]

According to the official reports, rabies was not diagnosed in Canada from 1900 to 1904. In 1905, sporadic cases in dogs were diagnosed clinically at North Portal and Oxbow in southern Saskatchewan. At that time, rabies was believed to have been introduced from North Dakota where the disease was known to have existed for some years. In June of 1905, a rabid dog bit a child in London, Ontario. This incident gave rise to the establishment of the first regulation in Canada relating to rabies "By Order in Council dated 19th August, 1905, in virtue of 'The Animal Contagious Diseases Act, 1903'" (27). No further cases were recorded for the next two years.

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[1]Unless noted otherwise, the information in this section on rabies during the period of 1900 to 1945 is based on the Reports of the Minister of Agriculture (1900 to 1902) and on the Reports of the Veterinary Director General (1903 to 1946).

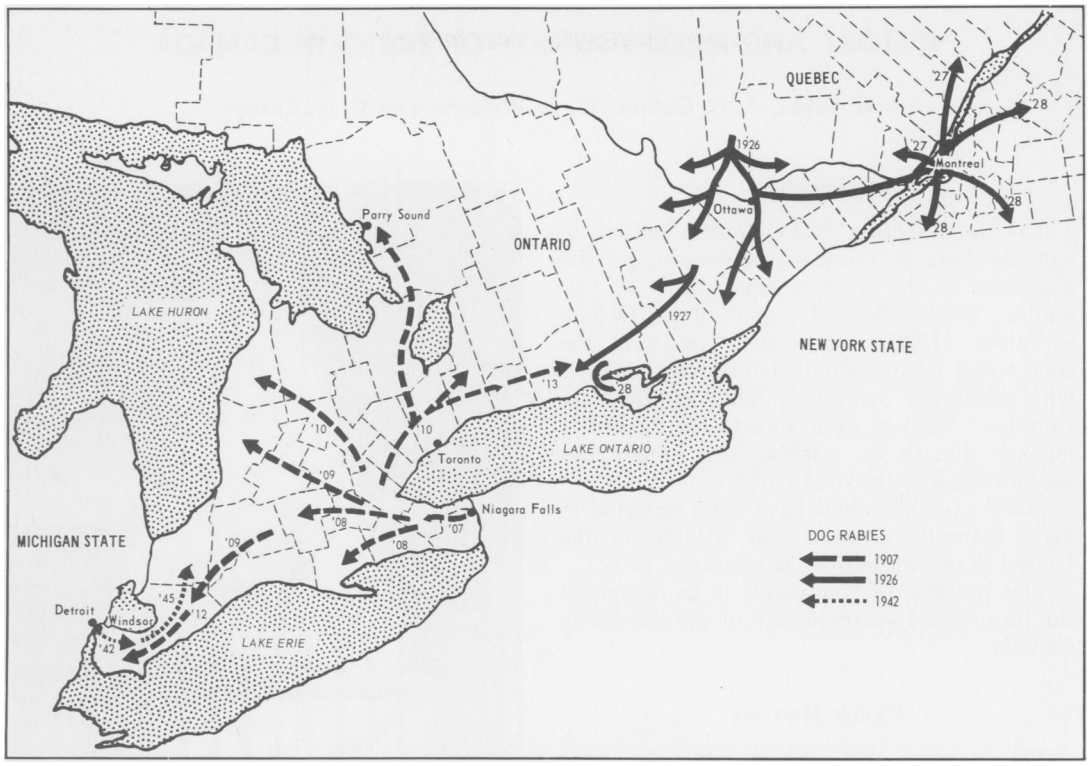

FIGURE 2. Rabies epizootics in southern Ontario 1907–1945.

In 1907, an epizootic of dog rabies started at Queenston, Ontario (Figure 2). A dog from the State of New York is said to have crossed the suspension bridge over the Niagara River and to have bitten several dogs in Queenston. During the following ten years, the disease spread over southern Ontario (Figure 2) as far as Windsor, Parry Sound and Peterborough. The epizootic which involved dogs, cattle, sheep and horses reached its peak in 1910, then slowly subsided until 1917 when the last cases were confirmed.

In 1907, sporadic outbreaks of rabies occurred at Shoal Lake, Manitoba and Moosomin, Saskatchewan. The infection was brought in by the dogs of American settlers. Isolated cases of rabies in dogs were also reported from Minnedosa, Manitoba in 1910 and from Qu'Appelle, Saskatchewan in 1914. The source of infection of a restricted outbreak of rabies in Red Deer, Alberta in 1909 was traced to a dog that had been shipped from southern Ontario to Alberta. In 1913, one suspected outbreak occurred in the Medicine Hat district. These small outbreaks of rabies were controlled by muzzling orders and effective quarantine. In 1914, an outbreak of rabies occurred in Victoria, British Columbia. The diagnosis of rabies was confirmed by histological examination in 38 dogs and one cow. Effective quarantine procedures prevented further spread of the disease.

No confirmed cases of rabies were reported in Canada between 1917 and 1925. In January 1926, an outbreak of rabies was observed north of Hull, Quebec (Figure 2). It quickly extended to the adjacent counties of Pontiac, Hull and Papineau in Quebec and the counties of Carleton, Russel, Grenville, Dundas, Lanark and Leeds in eastern Ontario. The disease was confirmed in Montreal in March. During the subsequent years, the epizootic expanded. It spread to the eastern townships of Quebec and as far as the counties of Glengarry, Frontenac and Northumberland in Ontario. The epizootic reached its peak in 1928 and then slowly subsided. The last cases were diagnosed in 1934. During this epizootic, rabies was confirmed in 262 dogs, 56 cattle, 33 sheep, 14 cats, six swine and two horses.

Inquiries as to the source of infection revealed that a few stray hounds were seen running at large in the district of Low, Quebec soon after the hunting season closed in November 1925. The peculiar action of these hounds attracted attention and they were known to have bitten several dogs. It was concluded that the infection was introduced by dogs brought

to Quebec from the U.S.A. for hunting purposes.

In 1927, an outbreak of rabies confined to six confirmed cases occurred in Calgary, Alberta but the source of infection was not established.

Rabies was diagnosed in a single dog in Toronto in 1937. Again, the source of infection was not determined. In 1939, a dog owned by a summer resident from the U.S.A. died of rabies on an island in the Muskoka district of Ontario. There were no contacts and, therefore, no spread of infection. During the same year, a more serious outbreak, in which rabies was confirmed in nine dogs, three cattle and one cat, occurred in southwestern Ontario in the counties of Huron, Bruce and Perth. The origin of this outbreak could not be definitely determined. It was assumed, at the time, that the infection was introduced by a dog owned by a summer visitor. The area was free of rabies the following year. In 1940, four cases of rabies developed among hunting dogs from the southern United States a short time after their entry into Saskatchewan for training purposes. No other cases occurred in Canada during 1940 and 1941.

An epizootic of dog rabies began in Essex County of southwestern Ontario in October 1942 (Figure 2). The disease spread to the neighboring counties of Kent and Lambton, increased in incidence until 1944 and disappeared by the end of 1945. The origin of this outbreak involving 116 dogs, seven cattle, three cats, one horse and one pig was not established.

The dog was the main vector of rabies from 1905 to 1945. Canine rabies accounted for 69% of the cases in the 1926–34 epizootic and 91% of the cases in the 1942–45 outbreak. Wildlife was apparently not involved, but sporadic cases of skunk and fox rabies were found in the State of New York during this period (12). Lack of awareness of wildlife as a potential source of rabies could hardly account for the lack of data. Thus, one may conclude that wildlife did not play a role in the perpetuation of the epizootics of this period.

1945 TO 1972

Three distinct epizootiological manifestations of rabies have developed in Canada since 1945 differing in their major vector species. Firstly, an epizootic of fox rabies originating in arctic Canada in the late forties spread southward involving all provinces from British Columbia to New Brunswick (Figure 3). This episode led to the present rabies enzootics in Ontario and Quebec (Figure 4). Secondly, an epizootic of skunk rabies spread into southern Manitoba from neighbouring North Dakota in 1959. This outbreak has slowly extended to the northwest through Saskatchewan and into Alberta (Figure 3). Skunk rabies is, at present, enzootic in these prairie provinces (Figure 4). Thirdly, rabies has been diagnosed in insectivorous bats in all but the four Atlantic provinces and would appear to be unrelated to the disease in terrestrial mammals.

1. *The Spread of Rabies from the Arctic to the South*[2]

Scant information indicates that rabies had been present in the Arctic for a long time. The earliest record of a rabies-like disease in the Arctic appears to be that of Colan (6) who describes a canine madness, much resembling rabies, to have occurred at North Greenland in 1859. In 1907, a disease considered to be rabies was prevalent in the lower Kuskokwim country in Alaska. This epizootic was thought to be rabies since several dogs bitten by foxes had died (21). In 1914, a man died of rabies following an attack by a sledge dog near Candle, Alaska and a year later rabies was diagnosed in foxes of the Yukon river delta (10). In 1942, an old Eskimo bitten by a wolf at Noorvik, Alaska died of rabies six weeks after the attack. Another clinical diagnosis of rabies in a trapper was made at Barrow Hospital, Alaska in May 1943 (26, 32). Rabies virus was isolated from foxes and a wolf collected in Alaska in 1945 (32). In an epizootic in Alaska lasting from 1945 to 1947, rabies was confirmed by laboratory tests in seven foxes, three dogs and one wolf (32). Rabies was also diagnosed in Alaska each year during the period from 1949 to 1957, mostly in arctic foxes (*Alopex lagopus*) and red foxes (*Vulpes vulpes*) (26).

In the nineteen twenties and early thirties, there were numerous reports of an "arctic dog disease" in the Canadian arctic (9, 11, 25, 32). Freuchen (11) reported on the occurrence of rabies among sledge dogs, arctic foxes, wolves (*Canis lupus*) and ermines (*Mustela arctica*) in the North West Territories, particularly in 1922. Epizootics among sledge dogs caused

[2]Unless noted otherwise, the information on rabies in Canada during the period of 1945 to 1972 was mainly obtained from the diagnostic records and files of the three laboratories responsible for the diagnosis of rabies in Canada; i.e., the Animal Diseases Research Institutes at Hull, Que. and at Lethbridge, Alta., and the Animal Laboratory, Sackville, N.B.

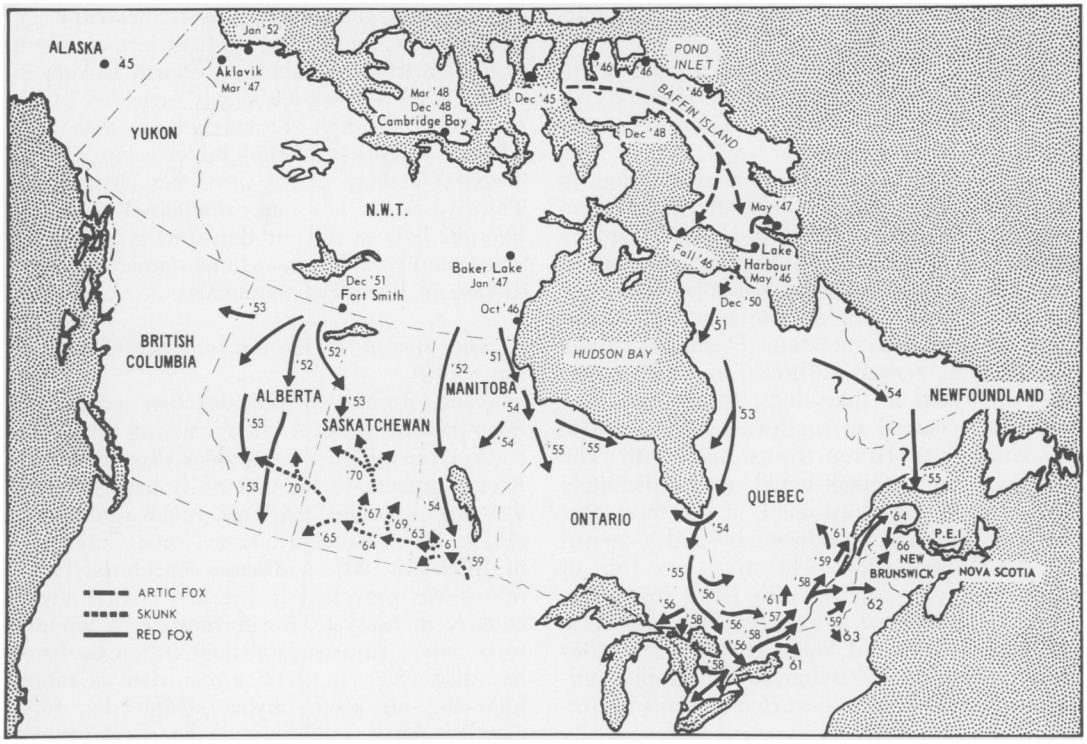

FIGURE 3. Rabies epizootics in Canada 1945–1972.

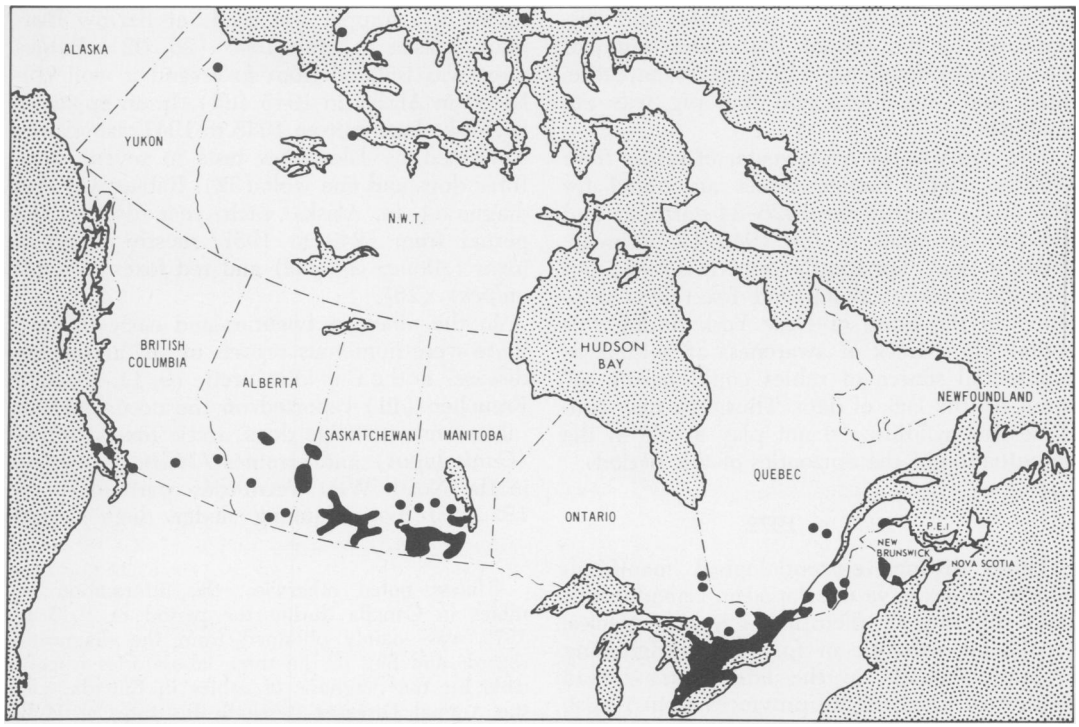

FIGURE 4. Geographical distribution of rabies in Canada in 1972.

great hardships to the Inuit because of their reliance on them for transportation. The Hudson Bay Company, interested in good trade relationships with the natives, sponsored an enquiry into the origin of the epizootics. Elton (9), who reported on this investigation, collected such a variety of reports that one is left with the conclusion that "arctic dog disease" was not one entity but that the different outbreaks were due to either fox encephalitis, distemper or rabies. He made the important point that the disease cycles usually coincided with population densities of foxes and that the periodicity of the cycles were three to five years, mostly four years.

Rabies was not diagnosed in Canada in 1946. Reports by the Hudson Bay Company, however, indicated that a dog disease resembling rabies had broken out at Creswell Bay, north of Fort Ross on Somerset Island, N.W.T. in December 1945. Twenty-three of thirty-nine dogs had perished. In February 1946, the disease was observed at Arctic Bay on Baffin Island, N.W.T., and later was reported to the east at Pond Inlet, River Clyde, Pangnirtung and in May 1946 at Lake Harbour (Figure 3). None of these Hudson Bay posts had had contact with the outside. There was evidence that the epizootic spread among arctic foxes, and that the disease was transmitted to sledge dogs by foxes. Because of the inaccessibility of these places, proper material for a laboratory diagnosis was not obtained. Whether the spread of the epizootic on Baffin Island, in fact, took the course and direction as demonstrated in Figure 3, is not definitely clear. The scant reports suggest this course. There is, however, still the possibility that rabies was enzootic at different places and that separate outbreaks of greater dimensions might have occurred because of an increase in the fox population.

In October 1946, a similar report of a rabies-like disease among foxes and sledge dogs was received from Eskimo Point in the Baker Lake district, N.W.T. In April 1947, Plummer (23, 24, 25) who had travelled to Baker Lake, N.W.T. for the purpose of investigating the disease, confirmed rabies in a fox by histological examination. This finding was later corroborated by virus isolation.

At the same time, a laboratory diagnosis of rabies was made on a wolf collected at Aklavik in the MacKenzie Delta in February 1947, and a few months later rabies was confirmed in specimens of a sledge dog from Frobisher Bay, Baffin Island. With the confirmation of rabies from the western, central and eastern Arctic, it became evident that rabies was widely disseminated in the north. Rabies has since been diagnosed in the North West Territories every year, excepting 1949, 1950, and 1957 (Table I). It would appear the disease had been enzootic in arctic wildlife, especially in foxes (*Alopex* and *Vulpes*) for a long time and epizootics of sylvatic rabies tended to flare up when the fox populations reached high densities. There are numerous reports describing sledge dogs being attacked and bitten by rabid foxes and wolves. The arctic climate would favour a long survival time of virus in frozen carcasses, and there is the possibility of transmission of the disease to scavenging sledge dogs via the oral route. Poorly fed sledge dogs that are close to starvation will feed on fox carcasses (13, 19). Infectious diseases may spread among dogs over great distances in a short time, as documented by the dissemination of distemper by an infected dog team that travelled from Churchill over Chesterfield Inlet to Southampton Island in 1934 (13).

Rabies was not officially diagnosed in 1949 and 1950. An epizootic of what appeared to be rabies was present in foxes and wolves in the MacKenzie delta in the fall of 1951. "Crazy" foxes and wolves were seen fighting with sledge dogs, which in turn became ill and died within a few weeks (20). Rabies was finally confirmed by laboratory tests in fox, dog and wolf in December 1951. Rabies persisted in the MacKenzie delta throughout 1952.

In 1951, rabies was also diagnosed on specimens obtained from widely separated localities, i.e. Fort Smith, N.W.T. near the Alberta border, Churchill in northern Manitoba, Lake Harbour on Baffin Island, N.W.T., and Sugluk and Povungnituk in northern Quebec.

In June 1952, a rabies epizootic began south of Fort Smith, N.W.T. and swept through the province of Alberta (Figure 3, Table I). In the same year, sylvatic rabies was also prevalent north of Forth Smith in the area of the Great Slave Lake. In Alberta, most of the epizootic remained confined to the northern part of the province, but isolated cases of rabies were found as far south as Lethbridge by February 1953 (3). The epizootic had spread over a distance of 700 miles within eight months. The rapid expansion of the epizootic to the south may well be attributed to the establishment of rabies within the coyote population in 1953. Coyotes are known to travel farther within a given period than red foxes do. To a lesser degree, the epizootic extended into Saskatchewan and northeastern British Columbia (Figure 3, Table I). The last rabies cases pertaining to this epizootic

TABLE I

NUMBER OF LABORATORY-DIAGNOSED RABIES CASES IN CANADA 1947–1972

	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	N.W.T.	Yuk.	Total
1947	—	—	—	—	—	—	—	6	—	6
1948	—	—	—	—	—	—	—	4	—	4
1949	—	—	—	—	—	—	—	—	—	—
1950	—	—	—	—	—	—	—	—	—	—
1951	—	5	—	2	—	—	—	4	—	11
1952	—	—	—	1	2	15	—	20	1	39
1953	—	6	—	3	4	98	7	11	—	129
1954[a]	—	6	4	16	10	50	—	2	—	90
1955[b]	—	1	95	8	2	40	1	8	—	156
1956	—	39	140	6	—	7	—	4	—	196
1957	—	266	64	—	—	—	2	—	—	332
1958	—	90	2,204	—	—	3	2	1	—	2,300
1959	—	18	943	21	—	—	—	5	—	987
1960	—	33	265	16	—	—	2	—	—	316
1961	1	94	628	50	—	—	1	7	—	780
1962	—	67	892	117	—	—	4	9	—	1,085
1963	—	57	864	156	2	—	2	9	—	1,088
1964	—	130	926	107	23	—	2	17	1	1,206
1965	—	233	1,264	45	25	1	2	12	—	1,581
1966	38	100	881	59	36	1	1	2	—	1,119
1967	57	129	1,068	32	48	—	2	17	—	1,353
1968	16	244	1,486	73	76	—	3	12	—	1,910
1969	51	250	1,892	61	63	—	5	5	—	2,307
1970	41	154	1,328	27	61	16	6	8	3	1,644
1971	32	92	1,302	53	49	24	11	1	—	1,563
1972	51	282	1,905	76	62	12	9	17	—	2,414

N.B. = New Brunswick
Que = Quebec
Ont. = Ontario
Man. = Manitoba
Sask. = Saskatchewan
Alta. = Alberta
B.C. = British Columbia
N.W.T. = North West Territories
Yuk. = Yukon
[a]Two cases in Labrador
[b]One case in Newfoundland

were found in eastern British Columbia and Saskatchewan in 1955 and in Alberta in 1956, except for an isolated outbreak in Alberta in 1958.

An extensive control program initiated to reduce the wildlife population and aimed at a decrease in the potential reservoir for rabies may have had an influence on the decline of rabies in Alberta (3). The extension of the same epizootic into Saskatchewan, Manitoba and British Columbia, diminished despite the lack of a special program of wildlife control, but the extent of rabies in these provinces was, from the beginning, much less than in Alberta.

Rabies entered Mantioba from the north in 1951 (Figure 3, Table I) and remained in the Churchill district for several years. Only a few cases of rabies were found in central and southern Manitoba. Again, the disease was most prevalent in the red fox population. In 1955, the disease spread from Manitoba into northwestern Ontario (Figure 3) where the epizootic petered out.

The main stream of rabies into eastern Canada came through northern Quebec (Figure 3). A rabies-like disease played havoc among the dog population at Sugluk, northern Quebec in the fall of 1950. By January 1951, roughly 30% of the fall dog population of Sugluk had either died or been shot due to the disease (19). Investigation into the nature of the disease revealed that the disease in dogs seemed to bear some sort of connection with the foxes. "At Sugluk during the winter of 1949–50 due to a shortage of dog food and a very heavy fox catch, the dogs were fed on fox carcasses for a good part of the winter and it was at Sugluk that the disease first appeared in the fall of 1950" (19). During the winter of 1950–51, several cases of "crazy" foxes attacking dogs and dog teams had been observed and subsequent to such attacks, dogs developed the disease. Laboratory tests on the fox and four dogs from Sugluk and Povungnituk, Quebec confirmed the diagnosis of rabies in March 1951.

It would appear that rabies had spread by foxes from Baffin Island, where the disease was prevalent in 1947, to the Sugluk area at some time prior to the outbreak there in the fall of

1950. Reports of a rabies-like disease in early 1951 accumulated from Cape Dorset, Baffin Island and Southampton Island and the diagnosis of rabies was confirmed in a dog from Lake Harbour, Baffin Island.

From the northern tip of Quebec, the rabies epizootic spread slowly southward. The disease was a major concern at Fort George and Eastmain, Quebec in early 1953 and moved into Ontario in 1954. In 1954, rabies was also confirmed in two dogs from Labrador and in another dog that had been shipped from Labrador to Newfoundland in 1955. Two rabid foxes were found on Anticosti Island in the gulf of St. Lawrence in 1955. These few data would indicate that the disease also spread southeasterly (Figure 3).

Great numbers of red foxes fell victim to the disease in the area of Kapuskasing, Ontario in 1955. The epizootic spread southward and reached southern Ontario in 1956. The incidence of rabies in southern Ontario in 1958 was the highest ever recorded in one province. In that year, rabies in red foxes accounted for roughly 50% of the 2204 laboratory-diagnosed cases. The important role of the red fox in the epizootiology of rabies in Ontario has previously been described in detail (16). Between 1954 and 1957, sylvatic rabies in Ontario was almost exclusively restricted to red foxes. In 1957, striped skunks (*Mephitis mephitis*) were found with rabies in the Muskoka district of Ontario and later in Gatineau and Labelle counties of Quebec. In the following years, the striped skunk emerged as the second most important wildlife vector for this disease in Ontario and Quebec (Tables II and III).

Rabies has remained enzootic in southern Ontario to the present time. The incidence of the disease has varied at different localities and waves of rabies appeared to be related to cycles of fox population density (16).

After 1957, the rabies epizootic progressed in Quebec in a north-east direction on both sides of the St. Lawrence River (Figure 3). There is evidence that rabies made its way from Ontario and Quebec into the adjacent states of the U.S.A. The seemingly isolated fox rabies observed in St. Lawrence County, New York in 1961 (12) may be due to extension of fox rabies from Ontario. The rabies epizootic obviously spilled over from Quebec into Maine in 1962 (17) and into Vermont and New Hampshire in 1963 (18). Maine had been free of rabies since 1951 (17) and Vermont and New Hampshire for nearly four decades (18). In 1966, rabies was carried into New Brunswick from Quebec and Maine (Figure 3, Table I).

TABLE II

COMPARISON OF THE NUMBER OF LABORATORY DIAGNOSES OF RABIES IN FOXES AND SKUNKS IN CANADA

Year	Rabies Cases	
	Foxes	Skunks
1955	78	—
1956	124	—
1957	163	5
1958	1,011	80
1959	469	128
1960	116	93
1961	373	108
1962	467	201
1963	356	335
1964	406	277
1965	587	262
1966	427	213
1967	597	279
1968	841	364
1969	1,072	356
1970	634	313
1971	598	345
1972	918	371

TABLE III

CASES OF RABIES IN VARIOUS WILDLIFE SPECIES IN CANADA 1947–1972

Species	Totals
Fox (*Vulpes vulpes/Alopex lagopus*)	9,310
Striped Skunk (*Mephitis mephitis*)	3,730
Bat (*Vespertilionidae*)	148
Raccoon (*Procyon lotor*)	118
Wolf (*Canis lupus*)	98
Coyote (*Canis latrans*)	79
Groundhog (*Marmota monax*)	17
Black Bear (*Ursus americanus*)	8
Lynx (*Lynx canadensis*)	5
Muskrat (*Ondatra zibethica*)	4
Badger (*Taxidea taxus*)	2
Beaver (*Castor canadensis*)	2
Buffalo (*Bison bison*)	2
Caribou (*Rangifer tarandus*)	2
White-tailed Deer (*Odocoileus virginianus*)	2
Rat (*Rattus norvegicus*)	2
Others	10

2. *Epizootic of Skunk Rabies in the Prairie Provinces*

It is interesting to note that rabies was not diagnosed in skunks in the prairie provinces prior to 1959 when an epizootic of rabies started among the striped skunk population in the area of Carman, Manitoba. This epizootic was apparently unrelated to the epizootic of fox rabies that entered northern Manitoba from the North West Territories in 1951. Only sporadic cases of rabies had been found in southern Manitoba from 1954 to 1956 and there had been no rabies observed in Manitoba since February 1956. There is the possibility that a small enzootic focus of sylvatic rabies

persisted unrecognized. It appears, however, more reasonable to believe that the outbreak of rabies among the striped skunks in southern Manitoba originated either in North Dakota or Minnesota, because rabies had been enzootic within the skunk populations of these two states for many years. Thus, it represents the northern extension of the belt of skunk rabies involving the mid-western states of the U.S.A. The epizootic in southern Manitoba which was almost entirely spread by striped skunks advanced slowly westward (Figure 3). It reached Saskatchewan in 1963 and Alberta in 1970 (Figure 3, Table I). The two single cases (one dog, one cow) in northern and central Alberta in 1965 and 1966 were obviously unrelated to this epizootic.

3. *Enzootic Rabies in Bats*

Rabies in vespertilionid bats does not fit into any of the described pictures. The first diagnosis of rabies in vespertilionid bats in North America was reported from Florida in 1953 (30). The yearly numbers of diagnoses of rabies in bats in the U.S.A. has increased since that time and is probably reflecting an increase of awareness of the public rather than a true increase (18). The first rabid bat in Canada was found in British Columbia in 1957 (2), but it is probable that the disease was present in bats in Canada long before. Bat rabies has been diagnosed in British Columbia every year since with the exception of 1959. Enzootic rabies in bats must be species-dependent. Except for one cat in 1969, no terrestrial mammal has been found rabid in British Columbia from 1957 to 1972. The presence of bat rabies in the absence of rabies in terrestrial mammals has also been observed in some states of the U.S.A. (29). Bat rabies has so far been found in six provinces of Canada, i.e. British Columbia, Alberta, Saskatchewan, Manitoba, Ontario and Quebec. Although it has been observed in a variety of bat species (4, 5), the greatest number of cases have been diagnosed in the big brown bat (*Eptesicus fuscus*).

The Role of Wildlife in the Dissemination of Rabies

Since 1947, rabies in Canada has been predominantly a disease of wildlife. Rabies is generally transmitted by bite and rabies epizootics in wildlife are primarily perpetuated within the vector species. A high incidence of rabies in one species, however, increases the chance of rabies in other species. An example of this is the infection of skunks by foxes in Ontario in 1957. Red foxes, arctic foxes and striped skunks are undoubtedly the most important vector species for rabies in Canada (Table III). Rabies occurs most frequently in foxes. The table does not distinguish between red foxes and arctic foxes, since some of the records of the specimens received were not always clear. The red fox samples, however, outnumber the arctic fox samples by far, the latter accounting for less than 1% of the total fox samples. It is difficult to obtain a quantitative estimate of the incidence of rabies in arctic foxes, since relatively few specimens from the North West Territories reach the diagnostic laboratories due to adverse conditions in collection and transportation. Nevertheless, it is certain that the arctic fox plays a major role in the epizootics in the North West Territories.

The predominance of rabies in striped skunks in the prairie provinces has been discussed. In Ontario and Quebec, this species is the second most important rabies vector. Rabies in skunks, unlike in red foxes, does not appear to be subject to great fluctuations over the years (Table II). One may explain this by the lower susceptibility of skunks to rabies virus infection when compared to that of foxes (28). Because of relatively lower susceptibility, rabies does not spread as dramatically among the skunk population as it does among foxes. It is also interesting to observe how the ranging habits of the major vector species influenced the speed of expansion of the epizootics. It took only eight months of rabies to spread over 700 miles (north to south) in Alberta in 1952–53, and this was likely due to the involvement of coyotes which travel comparatively long distances. In Ontario, the epizootic of red fox rabies proceeded more slowly. In fact, it required two years to advance from Moosonee on James Bay into southern Ontario. The slowest progress was made by skunk rabies in southern Manitoba and southern Saskatchewan (Figure 2). It took approximately six years to advance from Carman, Manitoba to the southwest corner of Saskatchewan.

Southern Ontario has had the highest incidence of rabies in Canada for 15 years. Rabies in southern Ontario is established in both major vector species, i.e. red fox and striped skunk, and as both species thrive in this area, one may predict that rabies will remain for years to come unless some effective control program can be developed.

Most specimens of rabid wolves were obtained from the North West Territories and from Ontario and Quebec. The majority of rabid coyotes were found in Alberta from 1953 to 1955. Rabies has never been diagnosed

to any great extent in raccoons except during the flare-up of rabies in the Ottawa region in early 1972. Twenty-five of the 35 raccoons diagnosed rabid in Canada in 1972 were submitted from the Ottawa Valley.

Eight cases of rabies in black bears (*Ursus americanus*) were diagnosed by laboratory tests in Canada, one in Alberta, three in Ontario and four in Quebec. Four case histories indicated that the rabid bears were acting violently. In two cases, men were attacked and bitten and in one of these cases, the victim was badly mauled. The total number of rabid bears is low (six positive of 20 specimens received between 1955–1972).

Rodents do not play a significant role in the epizootiology of rabies in Canada. The rodent species most frequently submitted for examination are squirrels and mice. However, the greatest number of rabies cases have been found in groundhogs (*Marmota monax*). Rabies diagnoses in other rodent species have been made only very rarely.

TABLE IV

LABORATORY-DIAGNOSED RABIES IN VARIOUS DOMESTIC ANIMALS IN CANADA 1947–1972

Species	Totals 1947–1972
Cattle	4,779
Dog	1,550
Cat	1,134
Sheep	548
Horse	332
Pig	308
Goat	22
Donkey	1

RABIES IN DOMESTIC ANIMALS

Prior to 1943, the known rabies in Canada was disseminated by dogs. Although foxes and skunks have been the main vectors of rabies since the disease spread from the North West Territories to the south, a great number of dogs and cats have still been victims of the disease (Table IV), and in turn, posed a threat to the human population. Since the introduction of efficient immunization with live virus attenuated in tissue culture, the number of rabies cases in dogs and cats has decreased. Nevertheless, rabies in dogs constituted 4.3% and in cats 3.9% of all rabies cases diagnosed in 1972. This indicates that a considerable number of dogs and cats are still not being vaccinated.

Despite their susceptibility to rabies, ruminants and horses do not play a significant role in spreading the disease. The number of rabid cattle, however, exceeded the number of rabies cases in any other species of domestic animals (Table IV). The loss to the cattle industry is considerably greater than indicated by Table IV, as a great number of clinically diagnosed cases are not included. The main source of infection for livestock is wildlife, chiefly fox and skunk. In 1972, data pertaining to the source of infection were available in 44 cases of rabies in domestic animals in Ontario. Foxes accounted for 23 cases, skunks for 15, raccoons for two, coyotes for two, a cat for one, and a dog for another.

HUMAN RABIES

Nineteen human deaths due to rabies have been recorded in Canada between 1925 and 1967 (1). Rabies, one of the most dreaded diseases, is obviously not such a menace to the human population of Canada as is, for instance, infectious hepatitis.

Epidemiological information on cases of human rabies is scant. The Animal Diseases Research Institutes at Hull, Quebec and Lethbridge, Alberta, have been involved in the diagnosis of four cases. A boy from Port Perry, Ontario died of rabies in 1958 after he had been bitten by a skunk. Another rabid skunk was the source of infection for a 14-year-old girl of Fort Huntington, Quebec in 1964. The girl fell ill 16 days after she was bitten on the face and died one month post-infection. In 1967, a four-year-old girl from Richmond, Ontario was scratched and clawed on the arm and in the face by a rabid cat. The girl received vaccination, but died of the infection some three months later. The last human case in Canada occurred in a 15-year-old boy from Meadow Lake, Saskatchewan in 1970. Investigations into the source of infection revealed that the boy had been bitten by a bat two weeks before the symptoms developed. The bite was apparently inflicted on the boy's face, but was of a very superficial nature.

Rabid cattle followed by foxes, dogs and cats were the source of most human exposures (Table V). The information contained in Table V is, however, of limited value because it does not express the extent of exposure to the individuals involved. The degree of exposure varied from case to case. In the case of a bite, it makes a difference whether the individual was bitten on a foot or on the face. It may be noted that three of the fatalities described above were due to wounds inflicted on the face. Whether virus was present in saliva and in what quantities, plays a role in the outcome of an infection. It is of interest

TABLE V

SOURCES OF EXPOSURE OF MAN TO RABIES 1972[a]

Domestic Animals		Wildlife	
Animal	Number	Animal	Number
Cattle	196	Fox	113
Dog	100	Skunk	28
Cat	80	Bat	4
Horse	44	Wolf	4
Goat	6	Raccoon	2
Pig	5		
Sheep	4		

[a]Diagnostic record of the Animal Diseases Research Institute, Hull, Quebec. Data for Quebec, Ontario, Manitoba and British Columbia in 1972.

in this connection that a greater number of experimentally infected skunks tend to have virus in the saliva than experimentally infected foxes and that the titer of rabies virus in the saliva of skunks is, on the average, higher than that of foxes (28). Rabies virus was isolated from the salivary glands of three of the four bats responsible for human exposures listed in Table V. These were identified as big brown bats (*E. fuscus*). The isolation of rabies virus from the salivary glands of these animals indicates that virus was present in the saliva. This demonstrates that rabies is and will remain a public health problem in Canada.

SUMMARY

Reports indicate that rabies was present in Canada 150 years ago. Dogs were responsible for three rabies epizootics in Ontario and Quebec and localized outbreaks in British Columbia, Alberta, Saskatchewan, Manitoba and Ontario in the first half of this century.

In 1947, rabies was diagnosed in the North West Territories from where it spread to the remainder of the country. The main vectors of these epizootics were arctic foxes (*Alopex lagopus*), red foxes (*Vulpes vulpes*) and striped skunks (*Mephitis mephitis*).

A distinct epizootic of skunk rabies began in southern Manitoba in 1959. It presumably originated in North Dakota. The epizootic slowly spread westward reaching Alberta in 1970.

Enzootic rabies in vespertilionid bats appears unrelated to the above mentioned epizootics. Bat rabies is presently recognized in the provinces of British Columbia, Alberta, Saskatchewan, Manitoba, Ontario and Quebec.

RÉSUMÉ

Certains rapports confirment l'existence de la rage au Canada, il y a 150 ans. Les trois épizooties qui sévirent en Ontario et au Québec, ainsi que les enzooties qui se produisirent en Colombie Britannique, en Alberta, en Saskatchewan, au Manitoba et en Ontario, dans la première moitié du siècle présent, étaient attribuables aux chiens.

En 1947, on diagnostiqua la rage dans les Territoires du Nord-Ouest. De là, la maladie se propagea au reste du pays. Les principaux vecteurs étaient alors le renard arctique (*Alopex lagopus*), le renard roux (*Vulpes vulpes*) et la mouffette rayée (*Mephitis mephitis*).

En 1959, un autre épizootie, en provenance vraisemblable du Dakota Nord, éclata chez les mouffettes, au sud du Manitoba. Elle progressa lentement vers l'ouest, atteignant l'Alberta en 1970.

L'enzootie qui affecte les chauves-souris de la famille des *Vespertilionidae* ne semble pas reliée aux épizooties que nous venons de mentionner. Elle sévit actuellement en Colombie Britannique, en Alberta, en Saskatchewan, au Manitoba, en Ontario et au Québec.

ACKNOWLEDGMENTS

The assistance of Mr. A. Bourgon in assembling data is gratefully acknowledged.

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