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Introduction

Control of rabies by reducing the density of potential vectors has been a controversial matter. Only 2 outbreaks of rabies in Europe are likely to have been completely eradicated by control, 1 in Dijon, France, in 1923, and the other in Corsica in 1943 (MacDonald 1980). Schnurrenberger et aL (1964) apparently controlled an outbreak of rabies in striped skunks *(Mephitis mephitis)* in Ohio by gassing dens and through the use of poison. An invasion of red fox (Vulpes vulpesl rabies in southern Jutland from Demark was initially halted by a gassing and poisoning campaign. However, in Great Britian, despite the fact that 100,000 foxes are killed annually in 1 region, the population shows no sign of decline (MacDonald 1980), suggesting population reduction is not an effective means of controlling fox densities in that area

Winkler et al. (1975) suggest controlling sylvatic rabies by lowering population densities has not proven adequate. In spite of the population reduction of foxes in an area of Germany during 1973-75, the population density appeared to increase (Stubbe and Stubbe 1977). Wandeler et al. (1974) suggest rabies does not sufficiently reduce the population density to curb an outbreak. However, they believed the combined effect of rabies and control effort were sufficient to reduce fox populations to a level at which rabies died out.

The province of Alberta has experienced a low incidence of rabies infections in wild and domestic animals. The first reported epizootic of sylvatic rabies in Alberta began in 1952 as an invasion of fox rabies from the Northwest Territories (Ballantyne 1958). Rabies swept through the province and reached the vicinity of Lethbridge by February 1953. The rapid spread (1,100 km in 8 months) was apparently due to the involvement of coyotes *(Canis latransJ* (Ballantyne and O'Donoghue 1954). During 1952-56 an extensive control program aimed at reducing the wildlife population was initiated. Approximately 180,000 foxes and coyotes were destroyed by trapping, poisoning, gassing and shooting (Vance 1975). Subsequently, Alberta remained virtually free of rabies for the next 12 years with only 2 diagnoses betweeff 1958-1%9 (Gurba 1974).

Rabies was first reported in the striped skunk in Alberta in January 1971, within 1.6 km of the Saskatchewan border (Gunson et al. 1978). Since then, 3 outbreaks of rabies in skunks have occurred in Alberta. Those have been restricted to (a) the Alberta-Saskatchewan border area, (b) the southern Alberta area (Forty Mile and Warner Counties), and (c) Newell County. Population reduction has been used to combat those outbreaks. The data presented here suggest that population reduction, along with other factors such as the selflimiting characteristics of the rabies virus, the geography of the areas, and the denning habits of the striped skunk, are playing a significant role in controlling outbreaks of rabies in Alberta skunks.

Study Areas

In 1970-71 a buffer zone (Border Population Reduction Zone - BPRZ) was set up along the Alberta-Saskatchewan border to combat an invasion of rabies in skunks from Saskatchewan. It consisted of a 29-km wide zone extending from the U.S.-Canada border, 600 km north to Cold Lake, Alberta (Fig. 1). Control has continued to the present Habitat varies from prairie in the south to aspen parkland in the north (Webb et al. 1967, Bird and Bird 1967). Since January 1980. rabies control was attempted in the southern Alberta area (Southern Population Reduction Zone - SPRZ) (Fig. 1) in the County of Warner, south of Highway 61, and the County of Forty Mile, south of Highway 61 and west of Range 8. That control area was surrounded by a number of geographical features including the Chin Coulee and Chin Lakes to the north, the St Mary River and Reservoir to the west, the Milk River Ridge. Reservoir and River to the south, and Pakowki Lake to the east The Newell County control area (Newell County Population Zone - NPRZ), approximately 150 km north of the SPRZ (Fig. 1). has been in effect since January 1982. Both the SPRZ and the NPRZ are within the short grass prairie ecoregion (Webb et al. 1967). Sampling was carried out in the area directly north of the SPRZ to determine if rabies had moved out of the control zone.

Materials and Methods

Alberta Agriculture, Fish and Wildlife Division, and county personnel were involved in control efforts. Although the majority of skunks were taken with live-traps or poison, some were removed by shooting and nightlighting. Wherever skunk sign was evident, National live-traps, baited with sardines, were set and examined daily. Toxicants were administered in the form of strychnine-laced bait cubes or chicken eggs. Dosage level was 30 mg strychnine per bait or egg (lcc of 396 strychnine). The baits or eggs were placed in culverts, rock -piles, burrows or under buildings and were accompanied by a conspicuous warning sign. Toxicants were not placed at sites close to human habitation. After 10-14 days, any baits or eggs not taken by skunks were retrieved and destroyed Control was concentrated in areas within 5 km (3 miles) of a known rabid animal.

(a) Warner County

The toxicants were used in selected townships in Warner County from 1980 to 1982. During that time, poisoned eggs were left at 64 sites in 13 different townships. In June 1983, an extensive program designed to systematically distribute poison throughout the county was Undertaken. The carcasses of poisoned skunks were recovered when possible. After the dosage was increased to 1.5 cc of 396 strychnine in each egg, carcasses were usually found within 5-10 m of the site where the egg was left

Extensive trapping was done in 5-km radial zones around locations of previously diagnosed rabid animals. Those zones were located throughout the county and trapping was well distributed. Trapping was also done in response to requests from landowners and wherever habitat suitable for skunks was identified Trapping effort decreased during the summer months, but otherwise was consistent between years except during January- March and October-November 1982, when effort was concentrated on the NPRZ in an attempt to halt the skunk rabies outbreak in Newell County.

LOCATION 0 F POPULATION REDUCTION ZONES IN ALBERTA 1970-1983

HIGH LEVEL

PEACE RIVER

4

GRANDE PRAIRIE

OLD LAKE,

GRANDE
CACHE

EDMONTON LLOYDMI

JASPE,R
JASPER
NATIONAL
PARK

.. ..RE~R

a'

BANFF

(b) County of Forty Mile

Control effort in the County of Forty Mile involved a combination of live-trapping and the use of toxicants. Trapping was restricted largely to the winter months, while toxicants were usually used after trapping was completed in an area. Personnel from the County and the Alberta Fish and Wildlife Division were involved in control within an approximate 2,104-km- area. Efforts were widespread throughout the County; however, trapping efforts were greatest in 1980 and declined thereafter.

Toxicants were used each year fom 1980 to 1983. Poisoned eggs were distributed during the spring and fall. Eggs or baits were left at a total of 117 sites within 29 different townships.

(c) County of Newell

Skunks were trapped during the same periods of the year during 1982-83, therefore a comparison of the trapping effort between years was possible. Toxicants were used from December 1982 to February 1983. Eggs or baits were left at 35 sites within 8 townships. Thirty-two (9196) of the sites were within 1 of the 5-km radial depopulation zones.

All skunks collected were submitted to the Animal Diseases Research Institute in Lethbridge, Alberta, for rabies testing. Most skunks killed by strychnine were not tested because most animals died away from the poison sites and were difficult to locate.

The trapping effort was determined to be the number of trap-nights (TN) in each area (1 trap set for 1 night = 1 TN) and the number of skunks collected per TN. Control efforts with toxicants were the number of poison-sites and the number of townships where poison was placed. Differences in prevalence and trapping efforts were determined using chi square analysis Mar 1974).

Results

A total of 401 cases of rabies in animals were diagnosed in Alberta between 1957-1983. The striped skunk has been the major vector of rabies in Alberta since December 1979, accounting for 155 cases up to December 31, 1983. One hundred and twenty-one of those were diagnosed from the SPRZ and 33 from the NPRZ

Southern Population Reduction Zone (SPRZ)

County of Warner

A total of 17,951 TN was accumulated between Janaury 1, 1980 and December 31, 1983, in a 4,139-km- area (Table 1).

One thousand, three hundred and six skunks were collected and tested for rabies infection (Table 1). Approximately 891 (o89b) were live-trapped; most of the remaining animals were shot. Between June and October 1983, at least 131 skunks died after consuming poisoned eggs. A valid comparison of the trapping data between years was not possible for the Warner County area due to the trapping effort occurring at different times of the year and at different locations. However, fewer skunks were taken in 1982 than in 1980-81 (Table 1). Prevalence of rabies in the total sample was 5.09'0. The annual prevalence was

ıary of control effort to reduce the numbers of striped skunks in southern Alberta?***

	Warner Count (SPRZ)				Fort Mile Count (SPRZ)				Newell County
	1980	19 1	1	1983	198	1998		1983	91983
; (TN) 37	90*	4100* y 3256		6805	1600*	455	390	298	3274
ɔped	148	239	84	420	192	49	45	33	386
	04	0.06	0.03	0.06	0.12	0.11	0.12	0.11	0.12
;kunks	54	403	158	491	204	71	67	62	567
	2								
‹s	17	17	2	29	17	5	1	0	30
***	6.7	4.2	1.3	6.0	8.3	7.0	1.5	0	5.3
ɛs	29	25	10	>150	40	29	11	37	35

greatest in 1980 (6.79b) and decreased significantly in 1981 ($P < 0.1$) and 1982 ($P < 0.025$). However, the prevalence in 1983 was significantly greater than in 1982 ($P < 0.05$) (Table 1). Total cost of the control program in the Counter of Warner was $213,800 for the period 1980-1983.

County of Forty Mile

A total of 2,743 TN was accumulated between January 1980 and December 1983 (Table 1). An estimated 325 skunks were killed with toxicants. From December 1980 to December 1983, 397 skunks were tested for rabies Approximately 319 (809b) were captured in livetraps. The number of skunks per TN was consistent between years (0.12±0.01). Prevalence of rabies in the total sample of skunks was 5.8% The annual prevalence was greatest in 1980 (8.39b) and decreased significantly in 1982 ($P < 0.05$) and 1983 $P < 0.025$) (Table 1). Only 1 case of rabies has been diagnosed in Forty Mile County between January 1982 and November 1985. Total cost of control for the County of Forty Mile was $41,600 for the period 1979-1983.

Newell Population Reduction Zone (NPRZ)

County of Newell

A total of 9,059 TN was accumulated between February 1982 and December 1983 (Table 1). The number of skunks/TN decreased significantly in 1983 over 1982 ($P < 0.001$) (Table 1).

From February 1982 to December 1983, 863 skunks collected in the County of Newell were tested for rabies infection. Approximately 842 (989'0) of those skunks were captured in live-traps and 12 were killed with toxicants. Prevalence of rabies in the total sample of skunks was 3.8%, but was significantly lower in 1983 (1.09io) than in 1982 (5.39:0) ($P < 0.005$) (Table 1). Rabies was not diagnosed in 194 skunk submissions between March and December 1983, however. 3 cases were diagnosed in 1984. Total cost of control in Newell County (1981-1983) was $64,900.

Outside SPRZ

During 1980-82 the area north of the SPRZ was sampled by live-trapping and a comparison was made of the trapping effort between Warner County and the area outside of the control zone. There were significantly more skunks per trap night taken outside of the control zone than in Warner County during 1980-82 ($p < 0.001$).

Discussion

The annual prevalence of rabies infection in striped skunks decreased signficantly in the SPRZ and NPRZ after 1980 (except SPRZ in 1983), and the overall distribution of rabies has not changed markedly since 1980. There has been only 1 case of diagnosed rabies in the Forty Mile County portion of the SPRZ since January 1982 (to Nov. 1985) and the NPRZ has only had 3 skunks diagnosed as being positive between March 1983 and November 1985. In addition, the BPRZ has been rabies-free since 1979. That situation is in contrast to the documented spread of rabies in other skunk populations (Hayles and Dryden

1970, McLean 1970, Tabel et al. 1974).

The epizootiology of rabies may be affected by topography of the habitat, the behaviour and ecology of the vector, and the effects of control efforts (Irvin 1970). In southeastern Alberta (west of Warner County), the Milk River Ridge provides an upland area of habitat unsuitable for skunks. The Milk River, Etzikom Coulee, and Chin Coulee may provide major deterrents to migrating skunks in the SPRZ on a north-south axis and Pakowki Lake may have a similar effect to the east

Striped skunks in a northern prairie habitat may spend 4-5 months in communal winter dens (Andersen 1981). Winter denning restricts contact between skunks to small pockets of the population, thus limiting the spread of rabies to a confined area. In addition, the virus may become latent in skunks during hibernation (Parker and Wilsnack 1966). Rabies virus has also been shown to be self-limiting in many situations (Irvin 1970) by lowering the population density of animals to a level below which there is no spread of rabies. These factors could all play a role in limiting the spread of rabies in southern Alberta.

The potential effects of the control program must also be considered. In the County of Forty Mile, the infection was initially widespread as evidenced in the survey trapping and by the number of rabid skunks submitted by the general public. Only 1 skunk collected since January 1982 has ~ been diagnosed rabid, although it must be noted that sample sizes were small because the majority of control was by poisoning and the skunks were not collected. However, rabid skunks in an area usually come to the attention of residents and would have been reported if present Skunks collected in a trapping program beyond the boundaries of the control zone have been uninfected with rabies. It is apparent that the trapping and poison program could have contributed to the control of rabies in the population.

The epizootic situation in the County of Newell appears to be distinct from that in Warner and Forty Mile Counties. In Newell County, the outbreak was very intense: that is, short-term, concentrated, and isolated. Control efforts were initiated immediately and concentrated in a small area, resulting in the removal of over 800 skunks in less than 2 years. It appears the density of skunks in the area may have actually contributed to a decrease in the population. However, the area was thoroughly checked and very few carcasses were found. There were signifcantly fewer skunks/TN in 1983 over 1982. The removal of so many individuals in a short time could have affected the rate of transmission of the virus. Presently, (Nov. 1985) the outbreak appears to be under control. Only 3 cases of rabies in skunks have been diagnosed between January 1984 and November 1985.

The County of Warner appears to remain the major problem area The apparent increase in the prevalence of rabies in 1983 may relate to the reduced control effort in Warner County in 1982 to combat the Newell County outbreak. However, it appears the control program may have had some effect on the skunk population since significantly fewer skunks were taken inside the control zone than outside between 1980-82. Different areas of Warner County were trapped per year which may have lowered the total density of skunks in the county. Also, only 4 cases of skunk rabies were diagnosed in Warner County in 1984.

It is impossible -to separate the effects of the natural epizootiology of rabies in skunks from the effects of the control program. The cyclic nature of rabies cannot be overlooked. It may be argued the decline of rabies in Alberta was due to a low point in the rabies cycle. However, adjacent Saskatchewan, which does not have a rabies control program, has similar habitat and skunk densities to Alberta (Andersen 1981), and skunk rabies has remained endemic since the early 1970's. A 4- to 5-year rabies cycle is evident in

Saskatchewan and 50-200 cases of rabies in skunks are diagnosed per year. In 1984, 162 skunks were reported rabid (Canada Agriculture). It appears unlikely a declining cycle of rabies could account for the decrease in rabies in Alberta because no cycle has been evident since the first skunk was diagnosed rabid in 1971 even though there has been constant sampling since that time. It may also be argued the peaks of rabies in skunks in 1980 and 1982 in Alberta were due to the increase in submissions from the population reduction program. However, rabies has been diagnosed in only 3 skunks from Newell County specimens submitted between March 1983 and November 1985 and Forty Mile County has been rabies-free between February 1982 and November 1985, despite sampling. Therefore it appears rabies in skunks is at a low level or non-existent in the 2 areas.

The removal of large numbers of skunks from a limited geographic area appears to have been effective in contributing to a lower prevalence of skunk rabies in Alberta The apparent success of the population reduction programs in Alberta may relate to the previous lack of endemic rabies in skunks, the biology of the vector in a northern habitat, the geographical features of the area, and the presence of an organized control effort which was mobilized rapidly once the disease was identified

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