

An Evaluation of Rabies Control in Skunks in Alberta

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INTRODUCTION

Epizootics of rabies in the striped skunk (*Mephitis mephitis*) were first reported in the United States in the early 1950's (8), although skunk rabies had been known in North America for well over a century (13). Since 1961, skunks have been the most frequently diagnosed rabid animal in the United States; accounting for 47% of all cases in 1976 (4). The first diagnosis of skunk rabies in Canada was apparently in 1957 in Ontario (21). The appearance of skunk rabies in the prairie provinces in 1959 (18) probably represented a northern extension of infection in the mid-western and northern states where the disease had been enzootic in skunks for some years (11, 16, 19).

Rabies was first identified in striped skunks in the province of Saskatchewan in 1963 (7). The westerly spread of the disease in skunks and domestic animals across Saskatchewan between 1963 and 1968 has subsequently been documented (7). By 1970 (Figure 1) the disease had reached the vicinity of the Alberta-Saskatchewan border despite attempts at local control in Saskatchewan by poisoning. The first skunk to be diagnosed as rabid in Alberta was collected in January, 1971 less than one mile from the Saskatchewan border.

Following the occurrence of rabies in two skunks, several coyotes (*Canis latrans*) and domestic animals in Alberta during 1970-71, a skunk depopulation program was established in 1971 and has continued to the present (1976). This control program included: reduction of numbers of skunks in an 18-mile wide (three townships) depopulation zone in Alberta adjacent to Saskatchewan stretching from Cold Lake in the north to the international border in the south (Figure 1); and depopulation of skunks within an

approximate three mile radius of the collection site of a laboratory diagnosed rabid skunk (1). The depopulations were intended to reduce the population of potential vectors, thereby preventing the spread of skunk rabies in Alberta. Governmental personnel removed skunks chiefly with the use of strychnine pellets and by trapping and shooting (1). Residents in the depopulation zone contributed to skunk control by shooting.

Effective programs of skunk rabies control have been conducted in other areas. Parker (12) reported that a concentrated poisoning campaign around Carlsbad, New Mexico, eliminated rabies in skunks for over three years. Schnurrenberger *et al* (16) reported a successful program of skunk rabies control in Ohio. In Montana skunk rabies control was apparently successful between 1966 and 1973 by poisoning skunks in radial and buffer control zones (personal communication). Such programs of rabies control by vector population reduction have often met with strong resistance and skepticism. Some have been cancelled following apparent success only to have the disease reappear (12). Many such programs have not adequately documented the specifics of reduction and very few have provided systematic monitoring of population numbers and infection rates.

The appearance of rabies in skunks at the Alberta-Saskatchewan border presented the opportunity to study the results of attempted disease control by skunk depopulation in a control area already established for Norway rats (*Rattus norvegicus*). This paper summarizes determinations of infection rates and skunk abundance, in and surrounding the control area and discusses the effectiveness of the control program.

MATERIALS AND METHODS

Skunks were examined for rabies at the Animal Diseases Research Institute (Western) [ADRI(W)], Lethbridge, Alberta by the fluorescent antibody technique (FAT) (5). The mouse inoculation test routinely followed negative FAT's in cases of human exposure.

Skunks were classified as either suspect or survey. Suspect specimens numbered 1768 (487 in Alberta and 1281 in Saskatchewan) collected by various individuals and agencies. Survey skunks numbered 1443 collected by the authors.

Survey skunks were collected primarily on a three-area basis; first, the depopulation zone, second, an approximate equal and adjacent area in the province of Saskatchewan and third, the remainder of Alberta. For the purposes of this paper "Alberta" when used in comparison with the depopulation zone denotes that area of Al-

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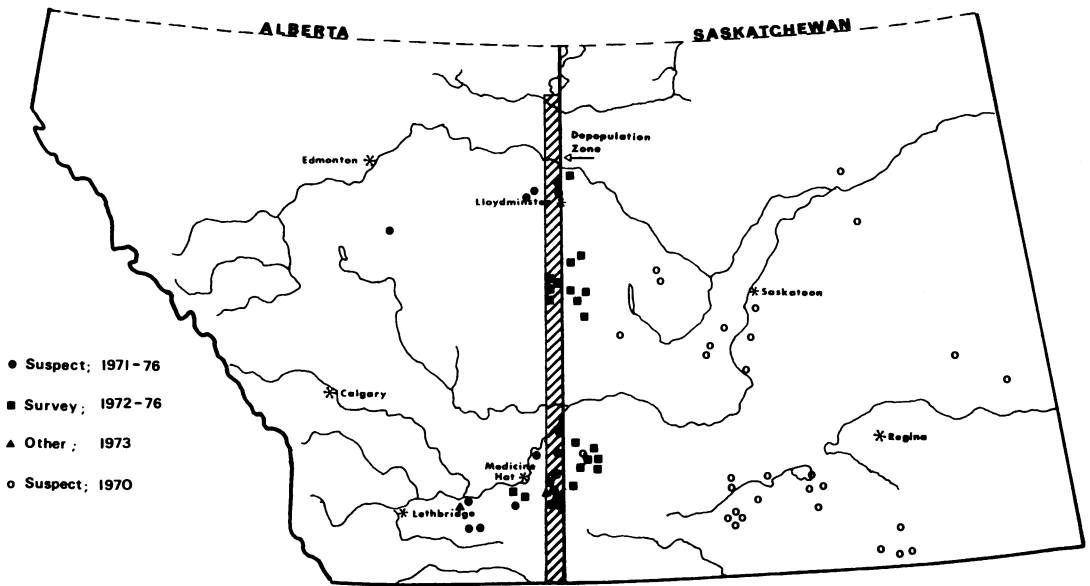


FIGURE 1. Distribution of rabid survey skunks (1972-76) and rabid suspect skunks in Alberta (1971-76) and Saskatchewan (1970).

berta west of that zone. Skunks collected in radial depopulations in Alberta and a special collection from an intensive study area in "Alberta" are included.

Methods of skunk collection included night-lighting and shooting, carbon monoxide gassing, live- and kill-trapping and shooting under buildings, in culverts, fields and other natural situations. Road-killed and control-poisoned skunks were collected when possible. We attempted to collect about equal numbers of skunks in each of the three major areas each season.

Building sites were inspected between 1972 and 1976. The number of sites where skunks were observed and the number observed were recorded. We counted skunks on permanent night-lighted transects (secondary roads) in the border area between 1972 and 1976 (20 mile transects in 1972 and 1973 and 25 mile transects from 1974 to 1976). Transects were paired between Saskatchewan and the depopulation zone. Fifteen pairs were completed in 1972, 16 between 1973 and 1975, and 17 in 1976. Light was provided by two roof-mounted aircraft landing lights of about 200,000 candle-power each. Alberta-Saskatchewan sequence was alternated daily to minimize potential bias introduced by possible peak periods of skunk activity.

Infection frequencies and night-lighted counts of skunks were compared using the Student's t-test. Site observations were compared using the 2 x 2 chi-square test.

RESULTS

Infection in Suspect and Survey Specimens

In Saskatchewan and Alberta respectively,

TABLE I

RABIES INFECTION RATES OF SUSPECT SKUNKS IN ALBERTA AND SASKATCHEWAN, 1970-76

Year	Proportion Rabid (n)	
	Alberta	Saskatchewan*
1970	0 (16)	33.3 (81)
1971	1.9 (105)	27.9 (111)
1972	1.7 (59)	42.7 (103)
1973	3.6 (112)	65.7 (327)
1974	4.1 (74)	53.8 (186)
1975	4.6 (66)	49.0 (194)
1976	7.3 (55)	50.9 (279)
1970-76	3.3 (487)	51.1 (1281)

*Records from ADRI(W) based on 654 rabid suspects.

from 1970 to 1976, 51.1% (654 of 1281) and 3.3% (16 of 487) suspect skunks were rabid (Table I). Highest yearly infection rates in suspect specimens were recorded during 1973 in Saskatchewan (65.7%) and 1976 in Alberta (7.3%).

Of 21 rabid skunks we collected, 14 were from Saskatchewan, five from the depopulation zone and two from "Alberta". Infection rates of survey skunks varied significantly (Saskatchewan vs. "Alberta", $P < 0.01$, Saskatchewan vs. Depopulation Zone, $P < 0.05$) between areas during 1972-76; 3.2% of 431 in Saskatchewan, 1.0% of 480 in the depopulation zone and 0.4% of 532 in "Alberta" (Table II). Yearly infection rates decreased from 36.8% in Saskatchewan in 1972 (all from fall in 1972) to 0% in 1975.

Seasonal rates among survey specimens were

TABLE II
ANNUAL RABIES INFECTION RATES OF SURVEY SKUNKS IN ALBERTA AND SASKATCHEWAN, 1972-1976

Year	Proportion Rabid (n)			
	Saskatchewan	Depopulation Zone	"Alberta"	Combined
1972	36.8 (19)	3.7 (82)	0 (65)	6.0 (166)
1973	4.2 (72)	0 (66)	0 (87)	1.3 (225)
1974	1.3 (75)	1.8 (110)	1.3 (159)	1.5 (344)
1975	0 (133)	0 (98)	0 (88)	0 (319)
1976	2.3 (132)	0 (124)	0 (133)	0.8 (389)
1972-76	3.2 (431)	1.0 (480)	0.4 (532)	1.5 (1443)

TABLE III
SEASONAL RABIES INFECTION RATES OF SURVEY SKUNKS IN ALBERTA AND SASKATCHEWAN, 1972-1976 COMBINED

Season ^a	Proportion Rabid (n)			
	Saskatchewan	Depopulation Zone	"Alberta"	Combined
Spring	2.0 (101)	0 (149)	1.2 (171)	1.0 (421)
Summer	0 (79)	0.8 (129)	0 (92)	0.3 (300)
Fall	6.4 (141)	2.7 (111)	0 (78)	3.6 (330)
Winter	2.7 (110)	1.1 (91)	0 (191)	1.0 (392)

^aSpring 03/01-05/31.
Summer 06/01-08/31.
Fall 09/01-11/30.
Winter 12/01-02/28.

highest during fall in both Saskatchewan (6.4%) and the depopulation zone (2.7%) (Table III). Rabid suspect skunks in Saskatchewan during 1970-76 were most common during April-May and winter (Figure 2).

Rabies was diagnosed in 26 skunks in Alberta during 1971-76, including 15 within the depopulation zone (Figure 1); eight from an area south of

the South Saskatchewan River and two west of Lloydminster, all west of the depopulation zone and one from central Alberta, 130 miles west of the border. Two other nonsuspect rabid skunks were collected by personnel of the Alberta Department of Agriculture. In the border area, rabid skunks were concentrated in certain areas (Figure 1).

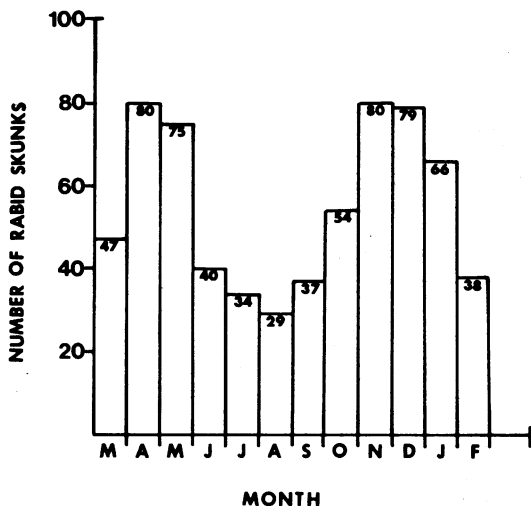


FIGURE 2. Monthly distribution of 659 rabid suspect skunks in Saskatchewan, 1970-76.

Numbers of Skunks

Between 1973 and 1975 the proportion of building sites at which skunks were observed increased from 0.12 to 0.18 ($P < 0.05$) in Saskatchewan, decreased from 0.15 to 0.10 ($P < 0.05$) in the depopulation zone and increased from 0.18 to 0.25 ($P < 0.2$) in "Alberta" (Table IV). In 1976 a reverse trend occurred in most areas with a decrease to 0.12 ($P < 0.10$) in Saskatchewan, and an increase to 0.14 ($P < 0.20$) in the depopulation zone. The "Alberta" index of 0.14 includes data from 104 sites examined in 1976 around the area of the rabid skunk at Wetaskiwin. The area was one of obvious low skunk density as skunks were observed at only one site. Excluding the Wetaskiwin data creates an "Alberta" index of 0.22 in 1976 suggesting little change in skunk occurrence between 1973 and 1976 in that area.

Numbers of skunks observed per 1000 miles of night-lighted transects increased from 46.7 in Saskatchewan in 1972 to 108.2 in 1976 ($P < 0.05$)

TABLE IV
PROPORTION OF BUILDING SITES WITH SKUNKS OBSERVED IN ALBERTA AND SASKATCHEWAN

Area	Proportion (n)				
	1973	1974	1975	1976	1973-76
Saskatchewan	0.12 (295)	0.13 (167)	0.19 (235)	0.12 (185)	0.14 (882)
Depopulation Zone "Alberta"	0.15 (221)	0.12 (125)	0.10 (507)	0.14 (142)	0.12 (995)
	0.18 (202)	0.22 (174)	0.25 (167)	0.14 (297)*	0.19 (840)
Combined	0.15 (718)	0.16 (466)	0.15 (909)	0.14 (624)	0.15 (2717)

*Includes 104 sites checked in 1976 following the Wetaskiwin depopulation in which skunks were observed at only one site; without Wetaskiwin data: proportion = 0.22 (193).

TABLE V
RELATIVE OCCURRENCE OF STRIPED SKUNKS ON TRANSECTS^a IN
ALBERTA-SASKATCHEWAN BORDER AREA, 1972-1976

Year	Skunks/1000 Miles		Ratio S/D	Significance ^b
	Depopulation Zone	Saskatchewan		
1972	20.0	46.7	2.3	P < 0.10
1973	31.3	53.2	1.7	P < 0.50
1974	17.5	57.5	3.3	P < 0.02
1975	35.0	105.0	3.0	P < 0.05
1976	51.1	108.2	2.1	P < 0.20

^a1972, 15 transects or 300 miles per province.
1973, 16 transects or 320 miles per province.
1974 and 1975, 16 transects or 400 miles per province.
1976, 17 transects or 425 miles per province.

^bStudent's t-test.

(Table V). During the same period observations decreased, but not significantly, in the depopulation zone [from 20.0 in 1972 to 17.5 in 1974 ($P < 0.9$)] and increased to 51.1 in 1976 ($P < 0.1$). The greatest Saskatchewan/depopulation zone ratio was observed in 1974. Sixty skunks were observed in the depopulation zone and 141 in Saskatchewan ($P < 0.01$) during the 5 year period.

The observed greater indices of skunk abundance on transects in 1976 were recorded primarily in the prairie biome (Figure 3) in which increases over 1975 occurred in Saskatchewan [88.0 to 193.3 ($P < 0.05$)] and increased, but not significantly, in the depopulation zone [72.0 to 106.7 ($P < 0.9$)]. In the prairie-parkland biome a decrease of skunk observations was recorded in Saskatchewan between 1975 and 1976 [154.3/1000 miles in 1975 to 85.7/1000 miles in 1976 ($P < 0.5$)]. Saskatchewan/depopulation zone ratios were 1.3 ($P < 0.4$) in prairie, 5.1 ($P < 0.01$), in prairie-parkland and 5.0 ($P < 0.02$) in parkland during the period 1972-76 (Table VI).

DISCUSSION

During the seven years, 1963 to 1970, rabies spread across southern Saskatchewan and became enzootic in that province during 1970-76. The mean yearly infection rate of suspect skunks from that province (51.1%) is comparable to that

found in other areas of enzootic skunk rabies; 61.5% of 808 in Illinois (17), and 71.0% of 2965 in Ontario (21). The much lower rate of infection of 3.3% of suspect skunks in Alberta and the difference in infection of survey specimens between Saskatchewan and Alberta of eight times (3.2%/0.4%) strongly suggest that skunk rabies has not become enzootic in Alberta during the study period.

Minimal infection in skunks in Alberta between 1970 and 1976 would appear to be primarily related to skunk control. Data from both site surveys and transects presented here demonstrate a reduction in numbers of skunks on the Alberta side of the border to and including 1974. Alsager (1) estimated a reduction in numbers of skunks of 37% in the depopulation zone during the first three years of the control program although he indicated reduction varied considerably between municipalities. His estimates were primarily based on the use and disappearance of strychnine pellets and numbers of skunks taken in live-traps. We consider his estimates to be somewhat high as evidence from follow-up surveys we conducted suggested less use of pellets than indicated (unpublished data). However, Alsager did not include estimates of skunks taken by residents although he did indicate that such removal occurred. Discussions with residents during field collections suggest that control by residents has

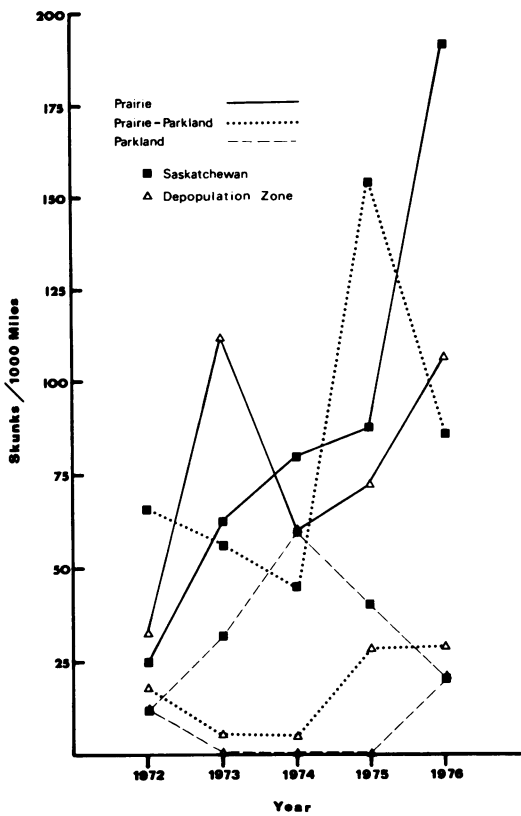


FIGURE 3. Trends in skunk abundance in the Alberta-Saskatchewan border area, 1972-76.

been a major source of skunk mortality following reporting of rabid skunks in the border area.

Between 1974 and 1976 numbers of skunks increased substantially (Table V) on both sides of the border. This increase was, in part, related to the mild winters of 1974-75 and 1975-76 as skunk production is high following mild winters and low following severe winters (2). Part of the increase on the Alberta side may be the result of dispersal of juvenile skunks from surrounding areas. Dispersal from Saskatchewan into the depopulation zone has been documented in a related field study (Andersen, personal communication). The increase in skunks in the depopulation zone may

also be a result of less intensive control since 1974. Control personnel have had to emphasize rat control measures and skunk control effort has tapered off somewhat following the impetus provided by initial enthusiasm for the task between 1971-73.

Success of control has also been affected by different behavior and use of habitat by skunks. In the prairie biome skunks make greater use of denning sites in more natural habitats as opposed to buildings (unreported data) where control has been primarily directed. Thus control has been potentially less effective in that area. In addition, skunks are more active and more dispersed during winter in the prairie biome, likely due to less severe winters, especially less snow. Mutch and Aleksuik (9) found movements of skunks limited by snow. These differences seemingly account for the greater numbers of skunks observed since 1974 and the spread of skunk rabies into interior Alberta in the prairie biome.

Our data suggest that epizootic as well as enzootic skunk rabies has occurred in the border area during the study period; six of 14 skunks (43%) collected in the Senlac-Major area of Saskatchewan during the fall, 1972 night-lighting exercise were rabid. Extent of mortality during that epizootic was not well defined, but no major decrease in numbers of skunks was noted in subsequent transect counts and site surveys. In contrast rabies has continued to occur in both the Lloydminster and Fox Valley-Schuler areas over the periods 1971-76 and 1973-76, respectively; those situations being more representative of enzootic rabies.

A number of investigators (11, 17, 19) in the north-central states have recorded a late spring-early summer peak in the incidence of rabies from suspect specimens. These investigators have related the April-June peak to accelerated interactions of skunks during the breeding season with subsequent manifestation of disease over the following three months. Similarly, in Montana between 1964 and 1975, Nesse and Seyler (10) reported 120 of 275 rabid skunks were collected in April and May with much reduced cases during winter months. However, Webster *et al* (21) found highest cumulative monthly incidence of

TABLE VI

OCCURRENCE OF STRIPED SKUNKS IN THE ALBERTA-SASKATCHEWAN BORDER AREA BY BIOME, 1972-1976

Biome	Skunks/1000 Miles			Ratio S/D	Significance*
	Depopulation Zone	Saskatchewan	Combined		
Prairie	81.6	109.1	95.0	1.3	P < 0.90
Prairie-Parkland	15.7	80.2	48.3	5.1	P < 0.01
Parkland	6.8	34.1	20.5	5.0	P < 0.01
Mean/Total	32.0	77.0	54.5	2.4	P < 0.01

*Student's t-test.

rabies in skunks in Ontario during December, preceded by a gradual increase during fall and a gradual decrease in January and February and a secondary peak, usually in April; a situation similar to that recorded in our study. According to these authors rabid suspect skunks from Manitoba also peak during winter. Hayles and Dryden (7) reported an increase of wildlife rabies, primarily skunks, during October to December in Saskatchewan between 1963 and 1968.

Skunks reach peak numbers following the bulk of parturition which occurs during May in Alberta. Females and young are concentrated in maternal groups in Alberta until mid-July (unreported data). Dispersal of highly mobile juveniles (2) begins in late July and extensive dispersal to new areas occurs during August and September. During this period juvenile skunks must encounter many other skunks in their wanderings. Exposure to infected animals during dispersal might explain our observation of highest seasonal infection rates in survey skunks in fall, assuming a mean incubation period of about 40 days, as recorded in captive skunks (6, 14, 15). Alternatively, the fall rate might be related simply to our collecting most of the rabid specimens during the aforementioned epizootic.

Interactions of adult skunks increase during late September and October with the formation of communal (winter) dens (unpublished data). Continued dispersal and joining of den groups by juveniles occurs during that period as well. Exposure to rabid individuals during this pre-denning activity in fall would seemingly account for the appearance of greater numbers of rabid skunks in November and December as recorded in our Saskatchewan suspect data and in suspect skunks from other Canadian provinces.

The infection rates of survey specimens collected in our study, ranging from 3.2% in rabies-enzootic Saskatchewan to 0.4% in "Alberta", appear to provide a more meaningful estimate of infection in populations as compared to data from suspect animals. Comparable data from survey skunks have been recorded in other studies. Verts and Storm (20) determined by mouse inoculation an infection rate of 8.6% of 362 striped skunks trapped in Illinois during an epizootic of skunk rabies between 1958 and 1964. Burkel *et al* (3) found an infection rate of 21.3% of 75 road-killed skunks from North Dakota.

The infection rates in the above studies of survey skunks are greater than that recorded in our survey specimens from Alberta, providing further support to the conclusion that skunk rabies had not established an enzootic infection in Alberta by 1976. Skunk depopulation appears to have been effective in reducing the spread of skunk rabies in Alberta throughout most of the border area with Saskatchewan. More concerted control of skunks in the prairie biome is recommended.

SUMMARY

Rabies infection rates of both survey and suspect striped skunks collected in Alberta between 1970 and 1976 indicate that skunk rabies was not enzootic in Alberta during that period, with the possible exception of an area surrounding Medicine Hat. Indices of skunk abundance from site surveys and night-lighted transects suggest skunk control was successful in reducing the number of skunks in a depopulation zone on the Alberta side of the border until about 1974, and further suggest such depopulation was not as effective since then, especially in the prairie biome. Differences in denning and other behavior between skunks in the prairie versus more northern habitats appear to account for the failure of skunk control in that area and the spread of skunk rabies into that part of Alberta.

RÉSUMÉ

Le taux d'infection rabique enregistré chez les mouffettes capturées en Alberta, de 1970 à 1976, mouffettes faisant partie d'un relevé ou tout simplement soupçonnées de rage, révèle que la rage n'existait pas à l'état enzootique chez la mouffette en Alberta, au cours de cette période, à l'exception probable d'une région avoisinant Medicine Hat. Des indices d'un nombre considérable de mouffettes aux endroits du relevé et sur les routes secondaires éclairées durant la nuit, laissent supposer qu'une campagne de dépeuplement permit de réduire le nombre de mouffettes, jusqu'aux environs de 1974, dans une zone située sur le côté albertain de la frontière. Ces indices laissent également supposer que, depuis ce temps, le dépeuplement ne s'est pas avéré aussi efficace, tout particulièrement au cœur des prairies. Des différences relatives à l'habitat et à d'autres aspects du comportement des mouffettes qui vivent dans les prairies, par rapport aux habitats situés plus au nord, semblent expliquer l'échec du dépeuplement des mouffettes dans cette région et la propagation de la rage chez les mouffettes de cette partie de l'Alberta.

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BOOK REVIEW

Veterinary Laboratory Manual. First Edition.

B. M. Bush. Published by Heinemann Medical Books Limited, London. 1975. 447 pages. Price \$25.00.

This book is a guide to the establishment and running of a veterinary practice laboratory. The presentation is logical and covers well the different fields of laboratory medicine including hematology, clinical biochemistry, hemostasis, urology, parasitology, bacteriology and cytology. General basic information is given on laboratory organization as well as on basic laboratory apparatus and instruments. The principles and methods for the collection and preservation of

laboratory samples are well covered. The basic laboratory techniques, including commercial kits, are described and the interpretation of laboratory results is discussed for small animals (dog and cat). Illustrations, especially those for parasite identification, are of interest. The chapter on the dispatching of samples to other laboratories gives valuable practical guidance concerning the type of sample to dispatch, the packing and postage, and the causes of the spoilage of samples. A subject bibliography is presented in an appendix. Similarly, although of limited usefulness in Canada and the United States, the names and addresses of manufacturers and distributors mentioned in the text are listed in an appendix. The book is recommended to veterinary students and to veterinarians interested in establishing a practice laboratory. *M. Fontaine.*