December 1985

PRELIMINARY STUDIES ON THE FEASIBILITY OF URBAN RABIES CONTROL

Richard C. Rosatte
Ontario Ministry of Natural Resources, Wildlife Branch, Research Section, Ontario, Canada

PRELIMINARY STUDIES ON THE FEASIBILITY OF URBAN RABIES CONTROL

Richard C. Rosatte, Ontario Ministry of Natural Resources, Wildlife Branch, Research Section, P.O. Box 50, Maple. Ontario, Canada LOJ 1E0

Abstract: A preliminary investigation was initiated in 1984 to determine the feasibility of an urban rabies control strategy which involved capturing, vaccinating and releasing skunks and raccoons in metropolitan Toronto, Ontario. Results indicate urban skunks and raccoons are utilizing extremely small home ranges and their movements are not extensive. Trapping data suggested a large proportion of the population of skunks and raccoons in the study area were captured during the first 4 nights of trapping. Capture data also indicated the presence of new animals in the study areas between trapping periods. The 3 study areas, which differed in human land-use classification, supported different population levels of skunks and raccoons.

Introduction

Rabies has been endemic in southern Ontario since the late 1950's (Johnston and Beauregard 1969). Between 1958 and 1984, 34,941 cases in animals were diagnosed in Ontario. The main carriers of rabies during that period were the red fox (Vul pes vul pest and the striped skunk *(Mephitis mephitis),* accounting for 44% (15,297) and 19% (6,513) of the reported cases, respectively (Agric. Can. Rep.). Twenty percent (6,864) of the diagnosed specimens were cattle. Domestic dogs and cats only accounted for 5.6% (1,969) and 4.7 (1,701) of the reported diagnoses, due to public awareness of rabies and vaccination campaigns. Although domestic pets represent only a small portion of the reported rabid animals, they are the main cause for exposure to humans. Dogs and cats were involved in 55% (1,114/2,027) of the human exposures in Ontario during 1984 (Table 1). However, it must be remembered that the primary source of infection to domestic animals is the wildlife rabies reservoir.

Costs for human rabies post-exposure treatment exceed more than $1 million per year in Ontario. Domestic animal vaccination, losses to livestock, public health department inquiries, diagnostic costs, and research and public awareness campaigns boost the Ontario rabies bill to more than $15 million annually.

The majority of reported rabies cases are from the rural areas of southern Ontario. Although still in experimental stages, the strategy for control is to air-drop rabies vaccineimpregnated baits along bush strips of rural southern Ontario. This technique can be very effective. During a trial in 1984, 64% of the sampled foxes had eaten a bait (vaccine placebo). However, only 34% of the sampled skunks ate a bait (Bachmann et al. 1986). More importantly, the rabies vaccine to be incorporated in the bait, which works well in foxes, is not effective in skunks. This presents a problem as skunks are the main vectors of rabies in urban areas of southern Ontario (Rosatte 1985).

Much greater numbers of rabid skunks (109) were diagnosed in metro Toronto during the 5-year period April 1, 1980-March 31, 1985, than during the preceeding 10 years (1970-1979) (73) (Fig. 1). Rabid skunks from metro Toronto also constituted 56% of all the diagnosed skunk cases in York County between April 1, 1980 and March 31, 1985 (109/194). In addition, human post-exposure treatment due to contact with potential rabid animals in metro Toronto during 1984 represented 1096 (192) of the total exposures for all of Ontario (2,027) (Table 1).

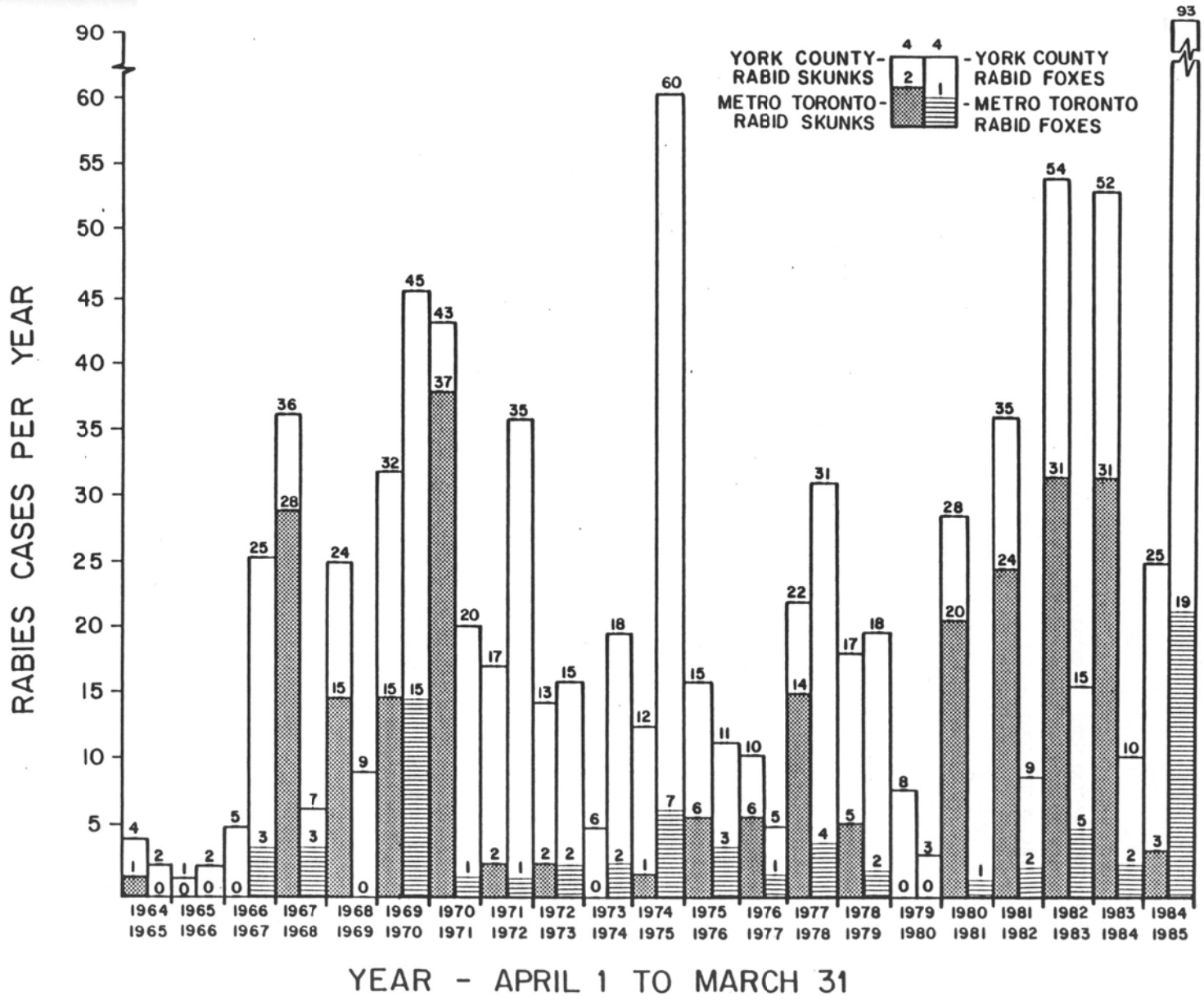

Figure 1. Number of diagnosed rabid skunks and foxes in York County and Metro Toronto 1964-1985.

Since the dropping of rabies vaccine baits by aircraft onto city areas is not feasible, and the current oral rabies vaccine is not effective in skunks, another approach for controlling rabies in urban areas is necessary.

During the spring of 1984 a preliminary investigation into the movements and habits of urban skunks was initiated in metro Toronto. Raccoons (Procyon lotor/ were studied as will. Only 12 raccoons were diagnosed as being rabid in Ontario during 1984, however, we felt it essential to gain background information on raccoons due to their great numbers in **metro Toronto, in case** control of rabies in that species is necessary in the future. During 1983, 1,906 cases of rabies in raccoons were diagnosed in West Virginia, Maryland, Pennsylvania, and the District of Columbia cad the disease is spreading north towards Ontario at as unprecedented rate (Winkler et al. 1985).

A follow-up program was initiated in 1985, under the direction of the Rabies Advisory Committee, to examine the feasibility of a control strategy for rabies in urban wildlife. This paper reports on the results of the 2 studies up to December 1985.

Study Areas

The study areas encompassed portions of metropolitan Toronto, a 600-km2 urban complex within York County in southern Ontario, Canada. The population of metro Toronto is approximately 2:5 million people and is dispersed throughout the cities of Toronto, Scarborough, North York, East York, Etobicoke and the borough of York.

During the 1984 preliminary investigation, skunks and raccoons were captured, radiocollared and released in a variety of land-use areas in metro Toronto including residential, industrial, parkland, field, cemetery and ravine areas.

The 1985 rabies control feasibility study focussed on 3 study areas within metro Toronto. Study area No. 1 (0.25 km=), located in Scarborough, consisted of 60% field, 35% residential and 5% industrial land-use areas. Study area No. 2 (0.25 km') in the city of Toronto was 40% residential and 60% forested-parkcemetery habitat. The third study area, located in Scarborough, consisted of 40% cemetery, 30% residential cad 3090 field-forest habitat

Materials and Methods

fl) Preliminary Study

Between May and September 1984, skunks and raccoons were live-trapped (Tomahawk #108, #106) in an attempt to radio-collai 30 animals (ZO skunks, 10 raccoons) to monitor their movements in an urban environment. Selected areas within metro Toronto (Scarborough. York. Toronto, East York, North York, Etobicoke) were trapped in response to residents phoning in locations of skunks and raccoons following a news-release. Live-traps, baited with sardines, were set wherever sign such as a den, smell or scats were present. Upon capture, animals were immobilized with Ketamine hydrochloride. Dosages (25-35 mg/kg) were determined from estimated body weight and later calculated after actual weight of the animal was known. Some juvenile skunks were handled without drugs, using a net or bag. Animals were then processed: that included extraction of a pre-molar tooth for aging (adults only), sexing, taking measurements and weights, attachment of ear-tags for

Table 1. Number of people receiving post-exposure rabies treatment per animal species involved • 1984.

Health Unit Area	Total	Cat	Dog	Cattle	Other Domestic	Fox	Skunk	Raccoon	Bat	Other
Scarborough	39	5	22	-	-	3	1	1	4	2
East York	4	-	3	-	-	-	-	-	-	1
North York	44	3	23	-	-	9	-	3	4	2
Toronto City	88	10	54	-	1	7	-	7	2	7
fork Borough	5	-	4	-	-	-	-	1	-	-
Etobicoke	12	-	7	-	-	1	-	1	3	-
Metro Toronto	192	18	113	-	1	20	2	13	13	12
Ontario	2027	458	656	227	64	224	126	65	78	129

identification, and blood sampling via cardiac puncture for serum antibody analysis. Processed animals were given tetracycline for marking teeth (1 ml intramuscular) and as an antibiotic, and were vaccinated with Imrab inactivated rabies vaccine and canine D.P.A.L. (distemper, parvo, adeno, letpo) vaccine, and then fitted with a radio collar. Collared animals were released at the point of capture. Their movements were monitored using a portable receiver (A.T.S.) and antenna system (Yagi). Locations of collared animals were usually determined once a. day, Monday through Friday. May 1984 - March 1985. All animals were not radio-tracked for the entire period as recapture of collared animals to obtain blood samples for determining rabies vaccine efficiency began in November. Home ranges of collared animals were calculated using the minimum area method through computer analysis (Voigt and Tinline 1979).

Between August 22 and October 4, 1984, 4 residential areas of metro Toronto were trapped (live-traps) for 14 consecutive nights in an attempt to obtain an estimate of skunk and raccoon abundance. Animals were captured, eat-tagged cad released at the point of capture. -

Agriculture Canada monthly rabies reports were examined to determine the occurrence of rabies in York County and metro Toronto for the period 1964-1985.

(2) Feasibility Study

Three study areas were selected in metro Toronto from a human land-use map, with attempts being made to choose an area which contained a diversity of habitat. Each area (approx. 0.25 km2) was divided into trapping grids, each 100 m x 100 m. Three live-traps were placed in each grid wherever sign such as a den, scats, or a runway was evident. Three different-sized traps (Tomahawk #105 skunk. #106 rabbit, #108 raccoon) were placed in each grid to determine if a particular trap size was selective for any one species Le. were raccoons more likely to be captured is a larger #108 trap versus a smaller #106 or #105 trap? Each trap was baited with sardines.

The study areas were trapped 1 at a time in succession for 10-day periods (9 nights) with 4 days off between trapping sessions during the period June 3-November 15, 1985. That allowed each area to be trapped 4 different times, enabling the blood sampling of recaptured animals for later vaccine effectiveness studies. It would also indicate the proportion of the raccoon and skunk population that could be captured; what proportion of vaccinated animals would seroconvert, and give an indication of movement of individuals into and out of the study areas over time.

Traps were set during the late afternoon or early evening and checked every morning during each of the 10-day trapping periods. Traps were closed during the day to avoid domestic animal captures. Each trap was marked with an identification tag containing a telephone number, Ont. Min. Nat. Res., and an identification number stamped on it. Some traps were anchored with a metal stake and chain to prevent trap movement by captured animals on hilly areas. A sign was posted at each trap site asking the public not to disturb the traps.

Each area was canvassed prior to setting traps to inform residents of the program, gain permission to trap on private property, and show residents how to release and reset traps should their domestic pets become captured.

Captured skunks and raccoons were immobilized with a mixture of ketamine hydrochloride and xylazine hydrochloride (rompun) (10:1) at as approximate dosage of 20-30 mg/kg

of ketamine. Animals were immobilized via hand-held syringe or with a drug pole containing a syringe-needle and plunger mechanism. Skunks were immobilized after the trap was covered with a plastic sheet to prevent the animal from spraying scent on the handler. After the animal was immobilized, it was processed as in the preliminary study, vaccinated against rabies (Imrab inactivated rabies vaccine) and allowed to recover. Selected animals were given 0.15 mg/kg of Yohimbiae in an attempt to reduce recovery time. Whey the animal was fully mobile, it was released at the point of capture. The blood sample was allowed to clot or spun is a centrifuge and the serum drawn off. Samples were stored in sera provials at -21°C for later rabies antibody analysis. The abundance of skunks and raccoons in each study area was estimated using the weighted mean method (Begon 1979).

Results

(1) Preliminary Study

Trapping Success

Nine hundred and twenty-two captures were made between May 1984 and March 1985 including 474 (51%) raccoons, and 139 (15%) skunks. Cats accounted for 85% (262) of the 309 "other" species captured. Trapping success was greater in May-October than NovemberMarch. Few animals were trapped between December-March, however raccoons were captured more often thaw skunks during this period (Table 2).

Movements

Raccoons: Twelve adult raccoons were collared between May 23 and June 21, 1984. Movements were monitored until March 1985, although trapping to re-capture animals and remove collars began in late October. Consequently, home ranges and movements were determined up to the date of re-capture which ranged from Oct. 19, 1984 to April 22, 1985. One animal lost its radio- collar is July and another 1 was killed by a dog in June. Movements and home ranges of these 2 animals were not determined due to insufficient data. The average home range of 10 adult radio-collared raccoons (6 males, 4 females) was 0.42 km= (range 0.07-1.37 km-2). The average distance moved from point of capture was 0.8 km (range 0.3-1.8 km). One raccoon whose radio-signal was lost on Dec. 17 was found dead 15 km north of the point of collaring on April 22, 1985. The 15 km movement was not included in the data. Raccoons were sometimes active during the winter period with movements up to 1 km occurring between November and March.

Skunks: Twenty-nine (12 adult, 17 juvenile) skunks were collared between June 1 and Sept. 26, 1984. Problems were encountered in keeping the radio-collars on the juveniles, especially during July and August, due to their small head size and neck circumference. As a result, 9 animals slipped out of their collars. One animal died, and 4 transmitters malfunctioned. Consequently, only 15 (9 adults, 6 juveniles) of the ' 29 collared animals could be used for home range and movement determinations. Mean home range of adult skunks was 0.65 km2 (range 0.08-1.44 km=). The average distance moved from the point of collaring was 0.86 km (range 0.4-2.1 km). Juvenile skunks moved an average of 1.3 km (range 0.5-2.6 km) from the point of capture and had a mean home range of 0.63 km-' (range 0.05-1.88 km=). Skunks did not move any appreciable distance outside their dens during the winter with few movements occurring between November and February. However, one skunk moved 300 meters during a mild spell in January and another moved 350 meters in February.

Table 2. Preliminary Study Trapping Success (May 1984-March 1985).

Month	Trap Nights	No. o Raccoons[1]	No. of Skunks[1]	No. o Others[1]	Animals per trap night
May	277	52	1	32	0.31
June	309	54	11	40	0.34
July	156	8	25	23	0.36
August	756	140	49	47	0.31
September	743	95	6	50	0.20
October	324	36	17	51	0.32
November	424	34	17	44	0.22
December	248	16	6	19	0.17
January	196	13	3	0	0.08
February	229	22	1	0	0.10
March	98	4	3	3	0.10
Total	3760	474	139	309[2]	$\bar{x}$ = 0.25

[1]includes recaptures
[2]included 262 cats, 21 groundhogs, 11 rats, 7 black squirrels, 4 red fox, 1 dog, 1 mink, 1 cottontail rabbit.

Denning Sites Between May 1984 and March 1985 radio-collared skunks and raccoons used several types of dens for shelter. Number of dens used, den type and frequency of use varied between animals and habitat type. Pregnant or lactating females used I den site until the young were mobile. Several den sites were used by individual skunks and raccoons during the summer and fall. Skunks tended to use a single den for winter denning beginning in late October - early November. However, raccoons utilized more than 1 site during the winter period and were more active than skunks.

Trees were used almost exclusively by raccoons as den sites in ravine areas (96%), whereas houses were more important as den sites in residential areas (40%). Sewer systems were utilized in cemetery areas far denning and foraging (69%). Skunks used burrows under houses and associated structures in residential areas (70%). Ground burrows were extensively utilized in field- ravine areas (80%).

(2) Feasibility Study

A total of 601 captures was made in the 3 study areas of metro Toronto between June 3 and October 2, 1985. Forty-one different skunks were captured a total of 153 times and 85 different raccoons were captured on 306 occasions. Other captures (plus recaptures) included 91 domestic cats, 41 groundhogs (Marmata monaxJ and 10 miscellaneous animals.

The most notable observation from the trapping data is the difference in relative abundance of raccoons and skunks between the 3 study areas. Study area No. 1, which consists of 60% field, 3596 residential, and 5% industrial land-use areas, has a considerable population of skunks but very few raccoons (Table 3). Conversely, study area No. Z has an enormous population of raccoons but a relatively low population of skunks (Table 3). The habitat of this area is 60% forested park-cemetery, and 44% residential. Study area No. 3, which has a more diverse land-use area of 4096 cemetery, 30% residential, and 30% fieldforest, has appreciable numbers of both skunks and raccoons unlike the 2 previous study areas (Table 3).

The number of animals varied among study areas and trapping periods. Generally, densities were lowest during the late spring-early summer when primarily adults were present, and highest in late summer-early fall when there were many juveniles (Table 4). A turnover in the population or presence of new animals, both skunks and raccoons, was also noted between trapping periods in each area as evidenced by the number of "new" skunks and raccoons captured per trapping period (Tables 3, 7).

Because df the great numbers of raccoons that were present in study area No. 2, 1 of the most significant findings during the study was that 1 trap was efficient for trapping skunks but largely excluded raccoons. Three sixes of live-traps were used. The smallest (#I05), captured skunks as frequently as the 2 larger traps (#106, #108); however, only 11% of the raccoon captures were taken by #105 traps and 97% of those were juveniles (Table 5).

The length of the trapping period (I4 days) revealed valuable information. The majority of different animals (x = 8790, range 78-I00) captured during 9 nights of trapping were captured during the first 4 nights (Table 6).

Captures during the trapping program have revealed the presence of considerable numbers of domestic cats at large in metro Toronto. Despite City and Provincial Health Department warnings to keep domestic animals confined in rabies prevalent areas, 90 cats were captured in the 3 study areas (Table 3).

Table 3. Comparison of feasibility study trapping results among the 3 study areas, June-October 1985.

	AREA 1			AREA 2			AREA 3		
Trapping Period	1	2	3	1	2	3	1	2	3
Date	June 3 -12/85	July 16 -24/85	Aug. 26 -Sept. 3/85	June 17 -26/85	July 29 -Aug. 7/85	Sept. 10 -19/85	July 1 -10/85	Aug. 12 -21/85	Sep. 23 -Oct. 2/85
Trap Nights	484	368	404	359	365	423	393	521	527
% Traps Tripped	8	9	8	48	41	26	12	16	12
Total Captures (includ. recaptures)	50	111	47	44	91	94	57	70	37
Total Skunks Captured	7	92	34	2	2	1	4	7	4
diff. skunks	4	15	13	2	2	1	3	6	4
New Skunk Captures[1]	4	14	7	2	2	1	3	5	3
Total Raccoons Captured	2	4	3	37	86	87	24	43	20
dIff.raccoons	2	4	3	21	34	32	13	19	11
New Raccoon Captures[1]	2	2	2	21	23	11	13	9	2
Total Other Captures	41	15	10	5	3	6	29	20	13
cats	14	5	5	4	3	5	27	17	11
grndhogs	25	10	5	0	0	0	1	0	0
misc.	2	0	0	1	0	1	1	3	2
Animals/Trap night									
Including tripped traps	0.10	0.30	0.12	0.12	0.25	0.22	0.15	0.13	0.07
minus tripped traps	0.11	0.33	0.13	0.24	0.42	0.30	0.16	0.16	0.08

[1]diff. skunks (raccoons) refers to different individual skunks (raccoons) captured per trapping period. New skunk (raccoon) captures refers to different individuals captured during all trapping periods .

Table 4. Relative Abundance of Skunks and Racoons/Study Area/Trapping Period (Density/0.24 km²) (S.E.).*

Study Area #1	Trapping Period June 3-12/85	July 16-24/85	Aug.26-Sept.3/85
Skunk Density	3.25 (2.2)	13.95 (1.4)	11.8 (2.7)
Raccoon Density	2.0	4.0	3.0
Study Area #2	**June 17-26/85**	**July 29-Aug.7/85**	**Sept.10-19/85**
Skunk Density	2.0	2.0	1.0
Raccoon Density	25.4 (6.6)	33.8 (5.1)	31.0 (4.2)
Study Area #3	**July 1-10/85**	**Aug.12-21/85**	**Sept.23-Oct. 2/85**
Skunk Density	4.0	8.5 (11.3)	4.0
Raccoon Density	15.9 (5.14)	20.4 (4.08)	11.7 (3.9)

* Density has been calculated using the weighted mean method for each of the study areas only (0.25 km^2). It is designed to be used as an abundance indicator between study areas only and is not to be extrapolated as a density estimate for any areas outside of the 3 study areas.

Table 5. Skunk and racoon Caputres/trap type.

Tomahawk Trap Type	105 (small)	106 (medium)	108 (large)
Skunks captured	47	60	44
% Captured per trap type	31	40	29
Raccoons captured	34*	123	149
% Captured per trap type	11	40	49

*97% juveniles captured between Aug. 1 and Sept. 3/85

Table 6. Table 6. Number of skunks and racoons trapped/day (days 1-4) as a percentage of the total number of skunks and racoons caputured during the 10-day trapping period.

		Trap-Night				
		1	2	3	4	% of Total 10-day Captures
% of Total Skunks captured (number)**						
Area	Trapping Period					
1	2	73 (11)	7 (1)	13 (2)	0	93
1	3	39 (5)	23 (3)	8 (1)	15 (2)	85
3	2	0	50 (3)	33 (2)	17 (1)	100
% of Total Raccoons captured (number)**						
Area	Trapping Period					
2	1	43 (9)	19 (4)	14 (3)	5 (1)	81
2	2	21 (7)	21 (7)	15 (5)	21 (7)	78
3	1	15 (2)	15 (2)	46 (6)	15 (2)	91
3	2	37 (7)	32 (6)	16 (3)	0	84

*data is not shown in areas and trapping periods where few animals were captured.
**excluding recaptures

Table 7. Percent of skunks and racoons captured per trapping period but not trapped during a previous trapping period.

Study Area	Species	Trapping Period 2	3
1	Skunk	93 (14)	54 (7)
	Raccoon	50 (2)	67 (2)
2	Skunk	100 (2)	100 (1)
	Raccoon	68 (23)	34 (1)
3	Skunk	83 (5)	75 (3)
	Raccoon	47 (9)	18 (2)

There was human interference with traps in study area No. 2. Between 26% and 4890 of the traps were tripped during the 3 trapping periods (Table 3). This proved to be the doing of an ardent anti-trapping animal-rights person in study area No. 2. Fortunately during almost 2 years of trapping in metro Toronto we have encountered only 2 such people in our study areas. Mgt residents were totally cooperative and supportive of the program.

Discussion

The overall objective of the study was to determine the feasibility of trapping, vaccinating, and releasing animals as a strategy for controlling rabies in urban areas. Before the strategy was investigated, the habits and behaviour of the target species, skunk, as well as its habitat were studied

One of the most important aspects of skunk and raccoon behaviour, as revealed by the preliminary study, was the type and frequency of dens utilized. In residential areas, dens associated with houses and their accompanying structures (garages, porches, steps, sheds) were used extensively by both species However, in ravine and park areas, skunks used ground burrows whereas raccoons preferred trees. We now know where to trap skunks and raccoons for control purposes. The extensive use of residential areas by skunks is also important when considering the potential for transmission of rabies to domestic animals and humans.

The preliminary study also revealed the two species were utilizing just about every type of land-use zone is metro Toronto. Animals were trapped in fields, ravines, parks, sewer systems, cemeteries and industrial areas, as well as residential areas. If rabies control in metro Toronto is going to be successful, each land-use zone will have to be defined as to location, habitat type and importance to skunks and raccoons. However, only 3 areas were sampled in metro Toronto and additional trapping in other areas will have to be carried out before abundance levels of skunks and raccoons can be extrapolated for all of metro Toronto.

The minimal movements and areas utilized by skunks and raccoons as determined from radio-telemetry is important when considering trapping and vaccination as a means of controlling rabies in urban areas. Sargeaat et al. (1982) noted skunks were capable of moving great distances (51-119 km). Raccoons have also been known to travel extensively (264 km) (Lynch 1%7). Rabies control will be more effective and less costly if animals are confining their movements to small areas. The area vaccinated should be at least twice the size of a skunk's home range to allow for movements, thus minimizing the chance of missing a proportion of the animals.

Trapping success was greater during May to October than in the late fall and winter. If a control strategy is going to rely on trapping animals for vaccination, knowledge of when to trap is of utmost importance. The data suggest at least 3 vaccination periods between June and November will be necessary to vaccinate a high proportion of the population of skunks and raccoons. However, is the current study, several skunk and raccoon home ranges probably overlapped the study areas due to the small size of each area (0.25 km=). This would account for the "new" animals being captured during each trapping period. In reality, a control program would cover a much larger area encompassing several home ranges, thus negating the requirement for more than 1 vaccination period.

The abundance of animals in an area is important when considering control of rabies. Assuming trap-vaccinate-release may be a feasible means of controlling rabies in skunks in metro Toronto, knowledge of the abundance of skunks and raccoons is necessary when

determining the cost and effort necessary to trap, vaccinate, and release a large percentage of the population Trapping indicated there are appreciable numbers of skunks in some areas of metro Toronto. The problem now lies in determining how to trap them more efficiently by excluding raccoons from the traps. However, we are now capable of selecting skunks over raccoons for capture by using the #105 trap during periods before juvenile raccoons are mobile or after they are too large to enter the trap. This is an approximately 6- to 8-week period.

The great number of cats taken in live-traps presents another problem. Exclusion from traps must be considered through trap-design and bait-type, but more important is to educate the public as to the danger of allowing domestic pets such as cats to roam in areas where rabies is present. The probability of a cat coming into contact with a rabid skunk may be quite high as they have been known to share the same den as a skunk. If the cat is not vaccinated, the resultant exposure to the owner or other human could be fatal because knowledge of the cat-skunk encounter would not be known.

The study indicated where there are appreciable numbers of skunks and/or raccoons, the majority of different animals can be captured in 4 nights of trapping. I am confident we are capturing the majority of individual animals in each study area per trapping period as few new animals were captured during the last 5 nights of trapping. However, there is still the possibility of trap-shy animals, although the data suggest the opposite due to the large number of recaptures.

The preliminary studies suggest trap-vaccinate-release may be a feasible method to control rabies in city areas of southern Ontario. However, before the feasibility of the control strategy can be assessed on a labor-cost basis, additional studies are needed. Of utmost importance is the need to determine whether human land-use areas supporting high numbers of skunks and raccoons in specific areas of metro Toronto support similar levels of animals in other areas of metro Toronto. Presently, we know which land-use areas support high numbers of skunks and raccoons, but we have not completed sufficient sampling to extrapolate for all of metro Toronto. Based on the costs of this year's research program, each city and borough of metro Toronto could initiate a rabies control program at an annual cost of under $20,000.

The strategy would involve live-trapping, vaccinating, and releasing skunks in 7-IO rabies-prone areas of each city. Each area could be trapped alternately for 5-day periods during June- October, thus allowing each area to be vaccinated 3 times. The costs of labor, traps, vehicle rental, gas, vaccine, bait and area that could be effectively trapped by 1 technician (100 kmZ) would break down to a cost of $2001km7.

Acknowledgements

The study was supported by the Rabies Advisory Committee, Dr. A. J. Rhodes, chairman. Several members of the Rabies Unit provided input including P. Kelly, F. Matejka~ P. Bachmann, D. Johnston, D. Yoigt, L. Virgin, and D. Briggs. Dr. C. D. MacInnes reviewed and E. Brolly typed the manuscript. A Chui drafted the figure. Ontario Ministry of Natural Resources, Wildlife Branch contribution No. 85-19.

Literature Cited

Agriculture Canada. 1985. Monthly rabies surveillance reports. 1958-1985. Food Production and Inspection Br., Animal Health Div.

Bachmaan, P., F. O. Matejka, R N. Bramwell, S. J. Fraser, D. H. Johnston, C. D. MacInaes, and D. R Voigt 1985. A field experiment of a fox bait for a liquid rabies vaccine. Subm. to Wi1dL Soc. Bull.

Begon. M. 1979. Investigating animal abundance. Univ. Park Press, Baltimore. 97gp.

Johnston, D. H., and M. Beauregard. 1969. Rabies epidemiology in Ontario. Bull. Wildl. Dis. Assoc. 5:357-370.

Lynch, G. M. 1967. Long range movement of a raccoon in Manitoba. J. Mammal. 48:659-660.

Rosatte, R G 19$5. The study of rabies in urban wildlife. Environ. Health Rev. 29:5-6.

Sargeant, A. B., R J. Greenwood, J. L Piehl, and W. B. Bichnell. 1982. Recurrence, mortality and dispersal of prairie stripped skunks, *Mephitis mephitis,* and implications w rabies epizootiology. Can. Field-Nat. 96:312-3I6.

Voigt. D. R, and R R Tinline. 1979. Strategies for analyzing radio-tracking data. Pages 387-404 in A Handbook on Biotelemetry and Radio-Tracking (G J. Amlaner, Jr., and D. W. Macdonald, eds.). Pergamon Press, Oxford and New York.

Winkler, W. G., J. S. Shaddock, and G Bowman. 1985. Rabies virus in salivary glands of raccoons (Procyon lotarl. J. Wild l Dis. Z1:297-298.