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RABIES CONTROL FOR URBAN FOXES, SKUNKS, AND RACCOONS

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ABSTRACT: Rabies is currently enzootic in many cities of southern Ontario. The Ministry of Natural Resources is utilizing two different tactics for the control of rabies in urban wildlife rabies vectors–oral immunization with baits (foxes) and vaccination by injection following live-capture (skunks and raccoons). Between 47 and 79% of the skunks and 61 and 76% of the raccoons were captured and vaccinated (Imrab) in a 60-km^2 urban area of Metropolitan Toronto during 1987, 1989. Only three cases of rabies in skunks have been reported since control began in 1987. Population increases of 120% for skunks and 40% for raccoons were noted since the rabies control program was initiated. Densities for raccoons and skunks in urban habitat were found to be as high as 56 and 36 per km^2, respectively. An estimated 56% of the foxes in Metropolitan Toronto were reached with rabies vaccine baits following distribution throughout the ravine systems and at fox pup-rearing den sites. To our knowledge, this is the first documentation of the use of a live-virus rabies vaccine for the control of fox rabies in a large metropolitan environment.

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INTRODUCTION

Ontario consistently has more reported cases of animal rabies than any other state or province north of the Rio Grande. In fact, since 1954, that province has accounted for more than 84% of the Canadian rabies diagnoses (Figure 1). The majority (95%) of the Ontario cases occur in a 98,000 km^2 area of agricultural and urban landscape in the southernmost part of the province (MacInnes et al. 1988). The virus originated from Arctic Canada (Tabel et al. 1974) with red foxes (Vulpes vulpes) and striped skunks (Mephitis mephitis) now being the main vectors of the disease (MacInnes 1987, Rosatte 1988). Since 1968, the Province of Ontario has sought to control this enzootic by vaccination of wildlife. The emphasis of the program has been through aerial drops of baits containing a Modified Live Virus rabies vaccine (Johnston and Voigt 1982, MacInnes 1988), but the vaccine, while effective in foxes, does not immunize skunks orally (Lawson et al. 1989, Rupprecht et al. 1990).

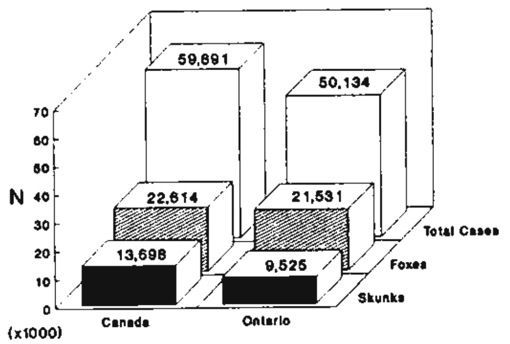

Figure 1. Rabies cases in Canada and Ontario, 1954-1988.

Although fewer than 5% of the Ontario rabies cases are reported from urban centers (Table 1), Metropolitan Toronto alone accounted for 10% of the provincial total of post-exposure human treatments in the period 1981-1988 (Table 2). This is quite interesting as Metropolitan Toronto constitutes less than 1% of the rabies endemic area of southern Ontario; however, that urban complex does have a population exceeding 2 million people.

Table 1. Rabies cases in major urban areas of southern Ontario 1980-1988[a,b].

Urban complex	Total cases	Skunks	Foxes
Metro Toronto	296	168	74
Ottawa/Kingston/Brockville/ Cornwall/Gananoque	200	89	75
Pickering/Oshawa/Whitby/Ajax	83	54	25
Mississauga/Oakville/Hamilton/ Brampton/Burlington	188	116	47
Urban total	767	427	221
Ontario total	19377	5082	8440

[a]Approximate figures because exact location of rabid animals was estimated, i.e., bordering urban/rural areas.
[b]From Agriculture Canada and Ontario Ministry of Health annual rabies surveillance records.

While foxes play the dominant role in the epizootiology of rabies in rural Ontario, skunks appear to be the more important vector in the major cities of southern Ontario (Johnston and Beauregard 1969, Voigt and Tinline 1982, Rosatte et al. 1987, MacInnes 1988). Foxes were, however, more frequently diagnosed with rabies than skunks in Toronto during 1985, 1988, and 1989 (Figure 2).

Table 2. Human post-exposure prophylaxis/animal species involved: 1981-1988[a]

Species involved	No. of people vaccinated Metro Toronto	No. of people vaccinated Ontario	% of total Metro Toronto	% of total Ontario
Dog	791	6417	43	32
Cat	340	4007	19	20
Other domestic	100	3976	5	20
Red fox	147	2525	8	13
Striped skunk	125	937	7	5
Raccoon	115	495	6	2
Bat	95	621	5	3
Other wildlife	130	1014	7	5
Total	1843	19992	100	100

[a]Figures from Ontario Ministry of Health case records.

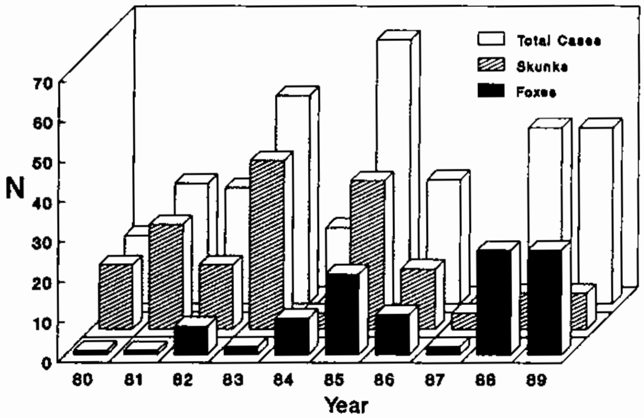

Figure 2. Rabies cases in metropolitan Toronto, 1980-1988.

In the absence of an effective oral rabies vaccine for skunks, the Ontario Ministry of Natural Resources adopted special tactics, live trapping and intramuscular vaccination to combat skunk rabies (Rosatte et al. 1987, 1990; Rosatte and MacInnes 1987). In view of the recent rise in fox rabies cases in Toronto, baits containing modified live-virus rabies vaccine were also distributed to immunize foxes.

This paper describes the rationale and preliminary results of efforts to combat rabies in Metropolitan Toronto.

METHODS

Skunk and Raccoon Rabies Control

Trap-Vaccinate-Release (T-V-R): In an effort to determine the feasibility of live-trapping skunks and vaccinating against rabies by intramuscular injection, we selected a 60-km^2 urban complex within the boundaries of Metropolitan Toronto, Ontario (lat. 43° 42'N, long. 79° 25'W) as our study area. Baited live-traps (Tomahawk #105, #106 or #108) were placed at densities of 50, 50 and 75 per km^2 of study area habitat during 1987, 1988, and 1989, respectively. Traps were set wherever signs such as dens, scats, or runways were evident in habitat categories classed as field, forested-park, residential, industrial, commercial, and groomed-grass (golf courses, cemeteries, etc.). The study area was divided into 60-1 km^2 cells. Each cell was trapped for 4 nights per week commencing the first week of July during 1987, 1989, and the first week of August in 1988. Twenty to 75 traps were placed in selected cells that had been trapped 1 week to 3 months previously to obtain an estimate of skunk and raccoon density as well as the percent of each population that was captured and vaccinated. Only 38% of the 60-km^2 study area was trapped during 1988 due to labour and funding shortages. Trapping continued until all cells had been trapped and a good portion re-trapped, usually until late November, a time which coincided with the winter denning period for skunks (Rosatte 1987).

Captured skunks and raccoons were ear-tagged for identification and vaccinated against rabies with a 1-ml intramuscular injection of Imrab inactivated rabies vaccine. The animals were then released at the point of capture. Blood samples were collected from selected animals via cardiac puncture following immobilization with ketamine hydrochloride and xylazine hydrochloride (Rompun) (30 mg/kg body weight ketamine, 10:1 ratio ketamine:rompun). Sera from those samples were later analyzed for rabies neutralizing antibody to determine the efficacy of the rabies vaccine (Kansas State University). Pre-molar teeth were also extracted from selected individuals for age estimation and bait-acceptance studies.

Skunk/Raccoon Baiting: Since oral vaccination is the most feasible approach to wildlife rabies control, we have been attempting to find the bait that will achieve highest acceptance in skunks. During 1989, we field tested two types of baits that could possible serve as vehicles for oral rabies vaccine delivery to skunks and raccoons (once an effective vaccine is developed). Beef tallow baits contained either cod oil or chicken essence as attractants. Tetracycline hydrochloride (100 mg/bait) was incorporated in the matrix of the bait to determine whether a skunk or raccoon ate a bait. A blister-pack (which would normally contain liquid rabies vaccine) was incorporated in each bait and contained 2 ml of distilled water. Baits were distributed throughout field or forested-park habitat in each of 16 1-km^2 cells within the 60-km^2 T-V-R area between June 22 and October 1, 1989. Density of baits varied between 25 and 149 per 0.04 km^2 of field or forested-park. That is, a maximum of 149 baits were put in any 1-km^2 cell. Each 1-km^2 cell was live-trapped 1 week post-baiting. Pre-molar teeth extracted during the T-V-R program were later sectioned in the laboratory and examined for tetracycline fluorescence according to Johnston et al. (1987) to obtain an estimate of bait acceptance.

Fox Rabies Control

Fox Den-Baiting: Since fox rabies was increasing in Toronto, we planned to distribute baits containing rabies vaccine in an effort to immunize foxes during 1989. A news release was issued to the Toronto area media during May 1989. The intention of the release was to inform the public of the Ministry's urban fox rabies control program but, more importantly, to request the public to report fox sightings and locations of active fox pup-rearing dens. Ministry personnel then determined if the sightings were valid by observation as well as by track and scat identification.

During the week of June 19-23, 1989, baits containing rabies vaccine (Lawson et al. 1989) were distributed at or near fox pup-rearing dens in Metro Toronto. Twenty baits per station were placed in 4 groups of 5 spaced approximately 3 meters apart in a single line or in a 2-meter radius around the den site. Baits were covered with debris. A conspicuous sign noting that the site was a baiting area for fox rabies control was posted at each station. Also, a telephone number was listed to enable acquisition of information on the program.

Baits were placed at stations during the early evening and collected the next morning during each baiting day. That tactic was employed to reduce the removal of the baits by nontarget species such as companion animals (dogs and cats). It also lessened the chance of human location of the baits. Any missing or partially eaten baits were replaced the following evening so that 20 baits per night were available for foxes at each station during each baiting night.

Baits and vaccine were manufactured by Connaught Laboratories Ltd., Willowdale, Ontario. Ingredients of the baits included a tallow-wax mixture and chicken essence as an attractant. Tetracycline (100 mg/bait) was added to the bait as a biomarker to determine whether a fox had eaten a bait through later examination of a section of extracted tooth (Johnston et al. 1987). Each bait also contained an identifying label and telephone number. A blister-pack, which was also labeled, was incorporated in the bait and contained 2 ml (liquid) of a modified live-virus rabies vaccine, ERA® strain propagated in BHK ^{21}cell line (Johnston et al. 1988, Lawson et al. 1989, Bachmann et al. 1990).

Ravine Baiting: Rabies vaccine-baits (same as described in the previous section) were hand-placed along the 6 major ravine systems of greater Metropolitan Toronto (Credit, Etobicoke, Humber, Don, Highland Creek and Rouge River systems) during October and November 1989 (Table 3). The objective was to vaccinate foxes that had not eaten a bait during the den-baiting program as well as vaccinate foxes dispersing into Metro Toronto. Baits were placed along both sides of the waterway in each ravine system with spacing between baits being approximately 50 meters. Some areas received more baits than others due to the mosaic characteristic of the urban landscape (i.e., forested parks were baited heavier than commercial property). The majority of baiting was accomplished by Ministry personnel on foot; however, water levels were sufficient to enable some of the areas to be baited using a canoe.

Public Relations

A very comprehensive communication program was mounted by the Ministry's Communications Services Branch to inform the public of the objectives of the urban rabies control program. News releases were issued both prior to and during the T-V-R and the fox-baiting programs. Fact sheets as well as a video were produced to further reinforce public education. Each study cell was canvassed prior to setting traps to inform the residents of the program and to gain permission to trap on private property. Fact sheets detailing the objectives of the T-V-R program were distributed in each study cell 1 week prior to trapping. A letter from the Minister of Natural Resources detailing program information was circulated to Metro Toronto school boards. Provincial and federal Ministries of Health, Agriculture, and Environment, and city health, animal control, parks and recreation, and police departments were also notified of the Ministry's activities. To further publicize the urban rabies control program, numerous radio and television interviews were completed with Ministry personnel.

Table 3. Distribution of rabies vaccine-baits in Metropolitan Toronto–October-November, 1989.

Baiting date	Ravine system	Number of baits	Km of baiting line	Baits/km of baiting line
October 16-17	Credit River	1584	26.0	60.9
October 18-19	Etobicoke Creek	864	17.1	50.5
October 16-20	Don River	2030	62.2	32.6
October 19-20	Rouge River	1372	21.1	65.0
October 23-25	Humber River	2162	32.0	67.6
October 23-27	Highland Creek	480	13.7	35.0
October 30-November 3	Metro golf courses	600	18.5	32.4
October 16-November 3		9092	190.6	$\bar{x}$ = 47.7

Data Analysis

An estimate of the percent of the population and skunks and raccoons that was captured during the T-V-R program was determined by dividing the number of different animals captured during the initial trapping period by the estimated population size. The range of percent captured was estimated using the standard error of each population estimate and the actual number of different animals captured.

During 1988, as the entire 60-km^2 T-V-R area was not trapped, an estimate for the skunk and raccoon population for the 60-km^2 area was calculated using the ratio of distinct animals and the ratio of capture success between 1987 and 1988 captures (Skalski et al. 1983). A modified Petersen Index was employed for animal abundance estimations utilizing capture-recapture data (Begon 1979). Variability within the capture data was tested using a nonparametric Kruskal-Wallis analysis of variance by ranks procedure (Kruskal and Wallis 1952, Sokal and Rohlf 1981). Contingency tables were then utilized to detect any interpopulation differences with respect to capture success per habitat type (Zar 1974).

A simple linear correlation was used to detect relationships between bait density and bait acceptance (Zar 1974). Chi-square was utilized to compare bait acceptance between and within skunk and raccoon populations (Zar 1974). A paired t test was employed to compare differences in population density between years (Zar 1974). Tests followed Zar (1974).

RESULTS AND DISCUSSION

Skunk and Raccoon Rabies Control

Trap-Vaccinate-Release: During 1987-89, 4,180 animals were captured in the 60-km^2 study area utilizing 42,337 trap-nights. Of those captures, 489 different skunks were taken on 856 occasions, and 1,049 different raccoons were captured 1,665 times (Table 4). Other captures (1,659) included 1,023 cats, 269 woodchucks (Marmota monax), 188 rats (Rattus norvegicus), 86 squirrels (Sciurus carolinensis), 69 cottontails (Sylvilagus floridanus), 2 foxes (Vulpes vulpes), 2 muskrats (Ondatra zibethica) and 20 miscellaneous birds.

Table 4. Capture success in the 60-km^2 Scarborough Study Area, 1987-1989.

Year	Trap nights	Total captures	Skunks T(D)[a]	Raccoons T(D)[a]
1987	14119	1432	195(123)	606(378)
1988	5902	700	214(114)	174(128)
1989	22316	2048	447(252)	885(543)
Total	42337	4180	856(489)	1665(1049)

[a]T = total captures, D = different animals captured.

Capture Success/Habitat Type: Capture success for skunks was greater in fields than in all other habitat types during 1987 and 1989 when comparing the 15 study cells (except field vs. commercial during 1989 where we could detect no difference) (H = 17.6, x^2 = 18.7-190.8, p <0.001). However, when comparing capture success between habitat types within a year, we could find no differences in the 1987 data (p >0.05). Conversely, during 1989, capture success was greater in commercial areas than all others except field and industrial areas (x^2 = 5.76-33.16, < 0.05 p <0.001). Capture success declined in order from field to commercial to industrial to residential to forested-park to groomed grass during 1989 (Figure 3). We also found increases in capture success for field, commercial, industrial, and forested-park habitats during 1989 as compared to 1987 (Figure 3) (x^2 = 3.86-35.24, <0.05 p <0.001).

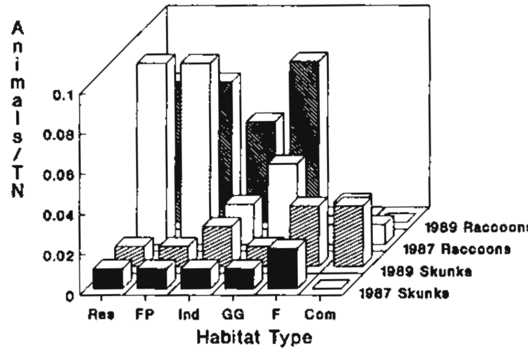

Figure 3. Skunk and raccoon capture success per habitat type, 1987, 1989.

For raccoons, we found capture success to be greater in forested-park and residential areas than in all other habitats during 1987 (H = 34.6, x^2 = 16.1-34.8, p <0.001). We could find no differences in capture success between forested-park and residential areas; however, more raccoons were captured in groomed-grass areas than in the three remaining habitat categories (x^2 = 5.2-32.7, <0.05 p <0.001)(Figure 3). Ranking for capture success during 1987 declined from forested-park to residential to groomed-grass to residential to field to commercial (Figure 3).

During 1989, raccoon capture success per habitat category changed with respect to the 1987 data. While capture success remained lowest in industrial, field, and commercial habitats, respectively (no detectable differences), we could not find any differences in capture success between groomed-grass, forested-park, and residential areas (which ranked in that order) (Figure 3). Raccoon capture success was, however, greater in those three areas than in the other habitat categories (H = 23.5, <0.05 p <0.001).

While comparing between year differences, we found that raccoon capture success increased between 1987 and 1989 in groomed-grass (x^2 = 12.6, p <0.001) and industrial habitats (x^2 = 12.4, p <0.001). However, we detected a decrease in capture success in forested-park (x^2 = 9.04, p <0.005) and residential areas (x^2 = 6.01, p <0.025) from 1987 to 1989 (Figure 3).

Population Estimate/Percent Captured: We estimated that the skunk population within the 60-km^2 area increased by 120% between 1987 and 1989 (Figure 4) (t = 3.75, p <0.0025). As well, 87% (13/15) of the individual 4-km^2 study cells experienced population increases of between 20-1250% (Figure 5). Areas with at least 10 to 20% of the habitat as field maintained skunk densities as high as 36/km^2. We captured between 47 and 79% of the skunk population within the 60-km² study area during 1987 and 1989 (95% Confidence Interval) (Figure 4). A lower proportion (40 to 50%) of the population was captured during 1988 as we only trapped 38% of the 60-km² area.

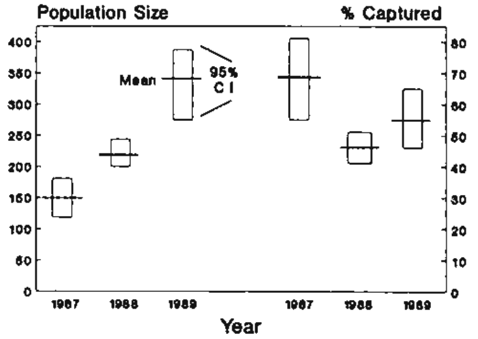

Figure 4. Skunk population and percent captured estimates for the 60-km² study area, 1987, 1989.

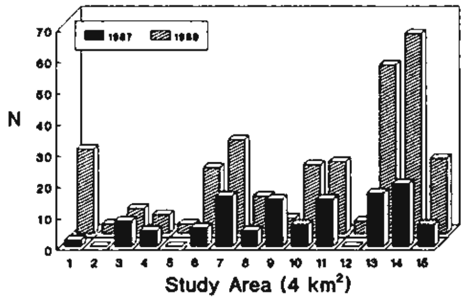

Figure 5. Skunk density estimates for individual 4-km² cells within the 60-km² study area, 1987, 1989.

Raccoon numbers also increased during 1987 to 1989, although not as dramatically as skunks. We estimated the increase in raccoons within the 60-km² area to be about 40% ($t = 2.17$, $p < 0.025$) (Figure 6). However, only 67% (10/15) of the individual 4-km² cells experienced increases in density of 14 to 333% between 1987 and 1989 (Figure 7). Areas with 10 to 30% forested-park had raccoon densities as high as 56/km². We feel that we captured between 61 and 76% of the raccoon population during 1987 and 1989 (95% Confidence Interval) (Figure 6). Percent captured estimates during 1988 were very low as we were targeting for skunks (i.e., only trapping areas with a lot of field habitat) (Figure 6).

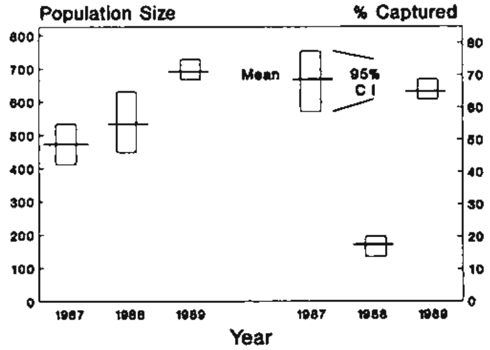

Figure 6. Raccoon population and percent captured estimates for the 60-km² study area, 1987, 1989.

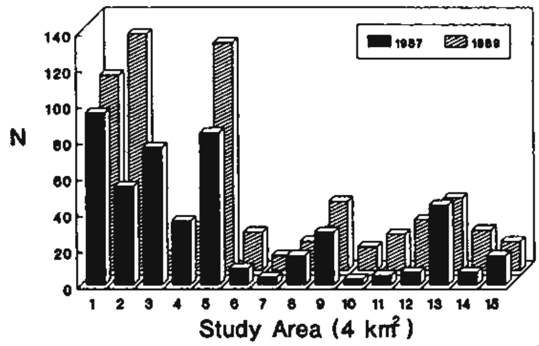

Figure 7. Raccoon density estimates for individual 4-km² cells within the 60-km² study area, 1987, 1989.

An important question to ask is why did skunk numbers increase so dramatically between 1987 and 1989. The most probable answer is that we may be controlling rabies in skunks within the study area. Previous to the initiation of our T-V-R program, rabies had been quite rampant within the study area (45 cases 1980-1987) (Figure 8). As rabies is a density-dependent disease, the population of skunks may have been at a low level within the study area when we began T-V-R in July 1987 (i.e., the area had just experienced a rabies outbreak during 1985, 1986). Now (1989) the population may just be approaching its normal carrying capacity in the absence of rabies. We expect a skunk rabies outbreak in our study area during 1990 (Figure 8). The next few years will be interesting in terms of what will happen to both skunk density and rabies prevalence within the 60-km² study area. Will compensatory mechanisms such as increased mortality (road kills), lower productivity, or an increase in other infectious diseases such as canine distemper or canine adenovirus come into play to limit the number of skunks within our study area?

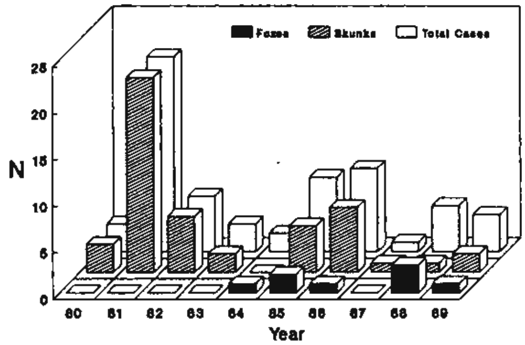

Figure 8. Rabies cases in the 60-km² T-V-R study area, 1980 to 1989.

While the increase in skunks may be explained by rabies control, the increased number of raccoons is not so easily accounted for. Raccoons in Ontario are apparently fairly resistant to the Ontario strain of rabies virus (i.e., less than 1% of Ontario annual diagnoses are raccoons). However, they are prone to sporadic outbreaks of canine distemper (Cranfield et al. 1984, Wojcinski and Barker 1986). This could partially explain the fluctuation in population numbers between years, i.e., the increase in population levels between 1987 to 1989 represent a natural recovery from a distemper outbreak during 1985 to 1986. However, before we formulate any concrete theories, we will have to examine in greater detail other factors such as differential mortality from road-kills in an urban environment, changing habitats due to construction within the city, and the movement of raccoons into the city due to feeding of raccoons by residents of Metropolitan Toronto.

We feel that T-V-R is having a direct effect on reducing the number of rabid skunks within our study area. We captured and vaccinated a significant proportion of the population during 1987 and 1989. Also, the vaccine is close to 100% efficient and is long-lasting in both skunks (>1 year) and raccoons (>2 yrs) (Rosatte et al. 1990). Based on rabies cases alone (only 3 since we began T-V-R compared to 45 between 1980 to 1987) we are gaining confidence that T-V-R is a feasible method for urban rabies control. In fact, programs using T-V-R are being initiated for raccoon rabies control in Philadelphia and Washington, DC, and in several Ontario cities for skunk rabies control. However, the critical period for our study area with respect to our success at rabies control will be the next few years as skunk densities are at or near their carrying capacity and they will be most susceptible to a rabies outbreak.

Skunk/Raccoon Baiting: A total of 1,211 placebo baits were distributed throughout a portion of the T-V-R study area during 1989. Of those baits, 612 contained cod oil and 599 had chicken essence as attractants. We found a positive correlation between bait density and bait acceptance for skunks and raccoons with the cod oil bait ($p < 0.05$). We could not find any difference in acceptance of either bait type between skunks and raccoons ($p > 0.05$); that is, raccoons did not show a greater preference for cod oil baits than did skunks. However, cod oil bait acceptance by raccoons was greater than for chicken essence baits ($p < 0.001$). We could not provide a valid comparison between bait acceptance for skunks as the skunk recapture sample size in the areas baited with chicken essence baits was inadequate.

Examination of teeth for tetracycline fluorescence is not an exact science. In some specimens the presence of fluorescence may be questionable (Johnston et al. 1987). In our sample, 21% of the raccoon teeth and 1% of the skunk teeth showed questionable fluorescence, i.e., a definite line due to tetracycline was not clear. Those teeth were considered negative for tetracycline. Therefore, our bait acceptance figures are minimum values and may have actually been higher in reality had we included the questionable teeth as positive.

Three of the 16 baiting areas were intensely ground-searched for baits and bait-components 1 to 2 weeks post-baiting. In one of the areas which had a high density of raccoons (>50/km^2), 22 blister-packs (which would normally contain the vaccine) were retrieved. All were chewed and contained no liquid. Only 1 partially eaten bait was retrieved. Baiting density in that 1-km^2 cell was 147 baits in 0.04 km^2 of forested-park (cod oil baits). Sixty-eight percent (34/50) of the raccoons had eaten a bait in the area as evidenced by tetracycline fluorescence in the teeth. The other two areas that were ground-searched had high densities of skunks (>20/km^2). Baiting density for those two 1-km^2 cells was 100 and 75 baits in 0.04 km^2 of field habitat, respectively (cod oil baits). Seventeen chewed blister packs were retrieved. Only 1 had any liquid remaining. However, 4 partially eaten baits were located in which the blister-packs were not punctured. Thirty-six percent (14/39) of the skunks had eaten baits in those two areas.

From our limited trials, it appears that both the cod oil and the chicken essence baits may serve as effective vehicles for the delivery of an oral rabies vaccine to skunks and raccoons. Correlation analysis suggests that baiting density is the key to achieving higher bait acceptance. That is, if we want to reach at least 60% of the skunks and raccoons with vaccine baits, we will have to be baiting at densities of 150 to 200 baits in 0.04-km^2 of field or forested-park in any 1-km^2 plot of urban habitat (that is between 150 to 200 baits/km^2). That figure approximates estimates suggested by other researchers for high raccoon/skunk bait acceptance in rural areas (Rupprecht et al. 1987, Johnston et al. 1988, Hanlon et al. 1989, Perry et al. 1989). To the contrary, our baiting density estimates are much lower (6 to 8 times) than those suggested for raccoons in a forested park within Washington D.C. (Hadidian et al. 1989). However, in our study area, fields or forested-park comprised less than 20% of each 1-km^2 study area. In the Washington D.C. study, 70% the study area was forested-park (Hadidian et al. 1989), which would account for the higher bait-density needed to achieve a significant acceptance rate (>60%).

The condition of retrieved blister-packs (chewed and no liquid remaining) suggests that both skunks and raccoons would have been vaccinated had they chewed at least 1 bait. However, our biomarker (tetracycline) was incorporated in the bait matrix and not in the blister-pack. Therefore, we do not know for certain that the animals which showed fluorescence in a sectioned tooth would have contacted liquid vaccine had it been incorporated in the blister-pack. We plan to answer this question during 1990 by running the same baiting trial as just described, with the biomarker dissolved in liquid within the blister-pack rather than in the bait matrix.

<u>For Rabies Control</u>

Fox Den-Baiting: During June 19-23, 1989, 1,170 rabies vaccine-baits were placed at or near fox pup-rearing dens (28 baiting stations) in Metropolitan Toronto. At least 10 baits were removed by animals from each of 18 of the baiting stations. Of the 164 blister-packs that were retrieved following an intensive ground search, 90% (147) were well chewed and had no vaccine remaining. Of the chewed blisters, an estimated 93% (136/147) were probably due to foxes as evidenced by tracks and visual observations in the area of the baiting station. Six percent (9/147) of the blister-packs were chewed by raccoons and 1% (1/147) by skunks as identified by tracks.

Of the retrieved baits, 69% (355/517) were not contacted by any species. However, 21% (107/517) were chewed by carnivores (fox, skunk, raccoon), 5% by Scuiridae (groundhog, squirrels, chipmunks) and 5% by Cricitidae (mice, rats, or voles) as evidenced by tooth impressions on the baits.

Due to the high percentage (90) of retrieved blister packs that were chewed, we probably vaccinated a good proportion of the foxes in the immediate vicinity of the pup-rearing dens. Foxes were actually observed at 10 of the stations while we were baiting. In fact, in three cases, we actually observed a fox taking a bait. We realize that den-baiting is site specific and can only serve as a supplement to wider broadcast baiting to vaccinate a significant portion of the fox population.

Ravine Baiting: During October and November 1989, 9,092 rabies vaccine-baits were distributed throughout the ravines of Metropolitan Toronto, as that is where we predicted most foxes would be living in a city environment. More than 190 km of ravines were baited at an average density of 47.7 baits/km of waterway (Table 3). Including the 1,170 vaccine-baits placed at fox dens during June, the bait density for the entire urban landscape of greater Metropolitan Toronto (800 km^2) during 1989 was 12.8 baits/km^2. The density of baits distributed for fox rabies control in the rural habitat of southern Ontario during 1989 was approximately 21 baits/km^2 (MacInnes et al. unpubl.). However, due to the habitat composition of most cities in southern Ontario, a good portion of the urban landscape is not suitable for fox habitation (i.e., we do not have to bait the entire urban area). Therefore a much more meaningful figure is the density of baits in baitable habitat, i.e., 47 baits/km of ravine waterway).

Efficacy of Oral Vaccination: There is a general consensus that if approximately 60 to 70% of a local fox population can be immunized, rabies will be eradicated or at least controlled (Steck et al. 1982, Schneider 1985, Voigt et al. 1985, MacInnes 1988, MacInnes et al. 1988). In our study, we included tetracycline in the baits to estimate the proportion of the fox population vaccinated through den and ravine baiting. Our problem is to collect a sample of foxes in a city environment of sufficient quantity to be of statistical significance. As we cannot depend on hunters and trappers to provide us with specimens as with our rural program, we are relying on road-kills and live-captures from our telemetry program to provide us with a sample to estimate bait acceptance and vaccine efficacy.

Fifty percent (6/12) of the foxes collected following the den-baiting program were positive for tetracycline. As well, 3 of 4 road-killed foxes collected following ravine baiting showed a positive tetracycline fluorescence in the teeth. Our limited sample suggests that we reached 56% (9/16) of the foxes in Metropolitan Toronto during 1989 through fox den and ravine baiting. As of this date we have yet to analyze blood serum samples for rabies neutralizing antibody to determine what percent of those foxes were immunized following contact with a bait. We hope to improve bait acceptance in 1990 by baiting ravines both during the spring and fall as well as targeting fox pup-rearing dens in June.

Public Relations/Safety Considerations: Although the vaccine utilized is considered safe and was approved for our use by Agriculture Canada, we still took many safety precautions in placing a live virus vaccine in a large metropolitan environment. During the summer den-baiting program, baits were removed during the day to lessen human and domestic animal contact. In addition, the baits were covered with debris to reduce their visibility to the public. Retrieving baits during the fall ravine-baiting program was not practical due to the size of the area involved. The results were still extremely encouraging. During 1989, approximately 11,500 rabies vaccine-baits (including 1,200 test baits without vaccine) were distributed throughout Metropolitan Toronto. In only three instances were we notified that a person had encountered a bait. Their only concern was regarding the nature of our rabies control program. This is simply amazing considering the fact that there are nearly 3 million people in the baiting area.

The low frequency of bait returns by the public was no doubt partially due to the camouflaged nature of the bait. However, the intensive communication program undertaken by the Communication Services Branch probably played a more important role by educating the public, particularly school children, not to handle the baits. In our opinion, education was the key to public acceptance of our program.

SUMMARY

The Ontario Ministry of Natural Resources has been utilizing a dichotomous approach to wildlife rabies control in city areas of southern Ontario. Vaccination of skunks by injection following capture appears to be a feasible tactic for urban skunk rabies control. Although oral vaccination of foxes with rabies vaccine baits is only in its infancy as a tactic for rabies control in urban areas, it as well appears to be a feasible approach. Much research and development with respect to increasing bait acceptance and finding more effective oral vaccines especially for skunks is desperately needed.

During 1990/91 we plan to expand both T-V-R and oral vaccination into other cities of southern Ontario in our efforts to control rabies in urban wildlife.

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