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Epidemiology of rabies in skunks in Texas

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Objective—To obtain epidemiologic information on rabies in skunks in Texas.

Design—Epidemiologic study.

Sample Population—Reports of skunks that had been submitted for rabies testing in Texas from 1953 through 2007.

Procedures—Reports were reviewed to obtain information on seasonality of rabies in skunks, seasonality of human and domestic animal exposure to rabid skunks, commonly reported clinical signs of rabies in skunks, domestic animals frequently exposed to rabid skunks, common scenarios for exposure of domestic animals to rabid skunks, disposition of domestic animals exposed to rabid skunks, age and gender of humans exposed to rabid skunks, and usual routes of exposure of humans to rabid skunks.

Results—On a yearly basis, the number of rabid skunks peaked in 1961, 1979, and 2001. On a monthly basis, the number of rabid skunks peaked in March and April. Over the study period, the percentage of rabid skunks from urban areas increased and the percentage from rural areas decreased. Striped skunks were the most common species. Dogs and cats were the domestic animals most frequently exposed to rabid skunks. On average, the highest numbers of humans exposed to rabid skunks were between 36 and 50 years old. Most humans were exposed through means other than a bite. Typical behaviors of rabid skunks were entering a dog pen, appearing outside during daytime, and attacking pets.

Conclusions and Clinical Relevance—Information on the epidemiology of rabies in skunks may be useful in planning and implementing local, state, and national rabies control and prevention campaigns. (*J Am Vet Med Assoc* 2009;234:616–620)

More than 90% of all laboratory-confirmed cases of rabies in Texas each year occur in wildlife species, with skunks and bats typically being the most commonly affected species. An analysis of reports[1] of laboratory-confirmed cases of rabies in Texas revealed that skunks were the most commonly affected species during 14 of the 20 years from 1988 through 2007, and nationwide, skunks were the most often reported wildlife species with rabies during the 1960s through the 1980s and have continued to be 1 of the 3 most common species since 1990.[a]

Rabies in skunks, therefore, has important public health implications, and a greater understanding of the epidemiology of rabies in skunks will be useful in the planning and implementation of local, state, and national rabies control and prevention campaigns targeted at skunks. Additionally, such information could be relevant to veterinarians in clinical practice when discussing rabies prevention guidelines with their clients. The purpose of the study reported here was to obtain epidemiologic information on rabies in skunks in Texas and the impact of rabid skunks on humans and animals in the state. Specifically, the purpose was to obtain information on the seasonality of rabies in skunks, seasonality of human and domestic animal exposure to rabid skunks, commonly reported clinical signs of rabies in skunks, domestic animals most frequently exposed to rabid skunks, common scenarios for exposure of domestic animals to rabid skunks, and disposition of domestic animals exposed to rabid skunks. Additionally, we wanted to obtain information on the age and gender of humans exposed to rabid skunks and the usual routes of exposure of humans to rabid skunks.

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Materials and Methods

Data for the present study consisted of reports of skunks that had been submitted for rabies testing in the state of Texas from 1953 through 2007. Skunks tested for rabies during this period were generally submitted because of concerns that they had exposed or potentially

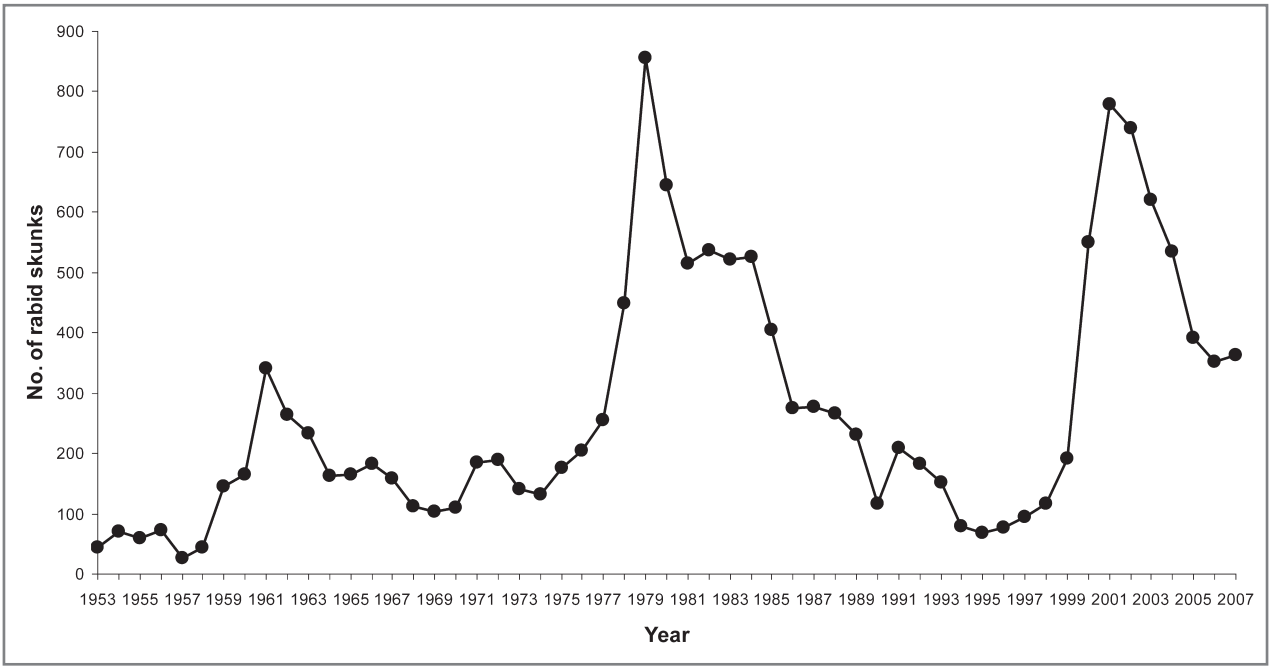

Figure 1—Number of laboratory-confirmed cases of rabies in skunks in Texas from 1953 through 2007.

exposed a person or domestic animal to rabies. Testing was performed by laboratories associated with the Texas Department of State Health Services in Austin, the El Paso City-County Health Department, the Houston Department of Health and Human Services, the San Antonio Metropolitan Health District, or the Department of Defense Veterinary Food Analysis and Diagnostic Laboratory at Fort Sam Houston. The duration of the subclinical viral shedding period in rabid skunks is not known. Therefore, the Texas Administrative Code required that any skunk that had bitten a human be euthanatized and tested for the presence of the rabies virus.[2] Submitted skunk specimens were tested for rabies virus antigen by means of direct immunofluorescence microscopic examination of brain tissue impressions. Antigenic analysis of specimens positive for rabies virus was performed with monoclonal antibodies against the viral nucleoprotein to identify rabies virus variants.[3,4] Atypical or unexpected results were confirmed by means of genetic analysis of the nucleoprotein sequence (ie, amplification with a reverse transcription–PCR assay followed by sequence analysis).[3] Typing of rabies specimens was performed by the Laboratory Services Section of the Texas Department of State Health Services. Rabies case investigations were performed by personnel from the Texas Department of State Health Services Regional Zoonosis Control, local health departments, or local rabies control authorities.

The type and amount of data available for each year of the study varied. Data on numbers of rabid skunks for the earliest years of the study were available only from historical copies of yearly summaries of statewide rabies cases, and the type and amount of information collected

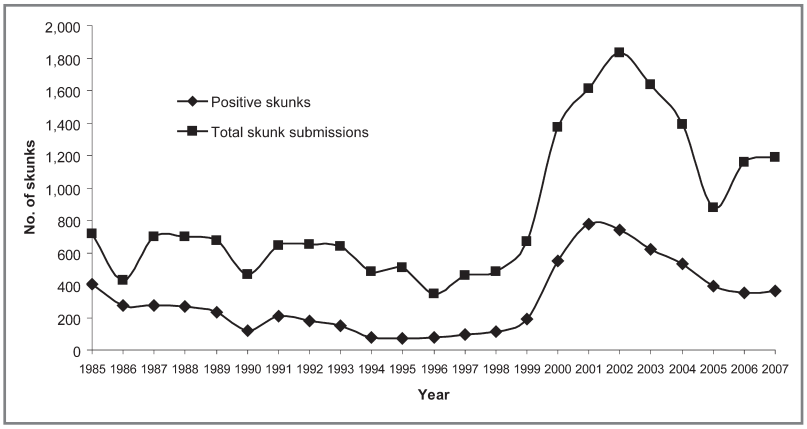

Figure 2—Number of skunks submitted for rabies testing in Texas from 1985 through 2007 and number confirmed to be positive for rabies.

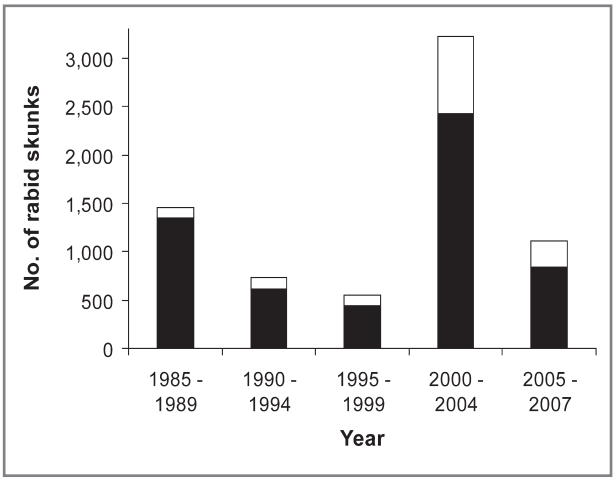

Figure 3—Location (urban [white bars] vs rural [black bars]) of rabid skunks in Texas from 1985 through 2007.

during case investigations generally increased over the years. For example, information on domestic animals and humans exposed to rabid skunks was not entered in the database in full-year increments until 1987, and information on rabies virus variants was available only during the later years of the study. Individual cases were reported according to the date that they were received at the testing laboratory, not on the basis of the date that testing was actually performed. Information on animal species other than skunks that were confirmed by laboratory testing to be infected with a skunk variant of the rabies virus was not included in the present report.

Results

Annual variations in numbers of rabid skunks—Examination of a graph of the total number of rabid skunks in Texas each year from 1953 through 2007 revealed peaks in 1961 (342 rabid skunks), 1979 (857 rabid skunks), and 2001 (778 rabid skunks; **Figure 1**). From 1962 through 1984, information was recorded only on animals positive for rabies; whereas beginning in 1985, information was recorded on every animal submitted for rabies testing in the state of Texas. When the total number of skunks submitted for testing from 1985 through 2007 was compared with the total number of skunks found to be positive for rabies each year, the general trend was that the number of skunks positive for rabies increased as the number of skunks submitted for testing increased (**Figure 2**). The percentage of skunks tested for rabies that were found to be positive for the virus ranged from 63.6% during 1986 to 13.6% during 1995.

Distribution of rabid skunks—Beginning in 1985, the latitude and longitude where each rabid skunk was located was recorded, and these data were analyzed with geographic information system software and 2000 census data[5] to classify skunks as coming from an urban or rural setting (**Figure 3**). During the 23-year period from 1985 through 2007, the percentage of rabid skunks located in rural areas decreased from 93% to 76% and the percentage of rabid skunks located in urban areas increased from 7% to 24%.

Monthly variation in numbers of rabid skunks—When data for 1985 through 2007 were combined, the numbers of rabid skunks peaked during March and April (**Figure 4**). A second, less substantial increase in numbers of rabid skunks occurred from October through December.

Species of rabid skunks—Five species of skunks have been identified in Texas[6]: the striped skunk (*Mephitis mephitis*), western spotted skunk (*Spilogale gracilis*), eastern spotted skunk (*Spilogale putorius*), hog-nosed skunk (*Conepatus leuconotus*), and hooded skunk (*Mephitis macroura*). From 1985 through 2007, species of 4,846 of the 7,068 (68.56%) skunks confirmed positive for rabies had been recorded at the time the specimen was received at the testing laboratory. Of these, 4,821 (99.48%) were identified as striped skunks, 18 (0.37%) were identified as hog-nosed skunks, 6 (0.12%) were identified as spotted skunks, and 1 (0.02%) was identified as a hooded skunk.

Rabies virus variants—Information on the specific rabies variant was available for 4,805 of the 4,955 skunks confirmed positive for rabies from 1994 through 2007. Of these, 4,760 (99.06%) were infected with the south-central skunk variant of the rabies virus (**Figure 5**) and 43 (0.89%) were infected with the hog-nosed skunk variant of the rabies virus, which is closely related to the south-central skunk variant. One skunk along the Texas-Mexico border was infected with the Texas fox variant of the rabies virus, and 1 skunk from the north-

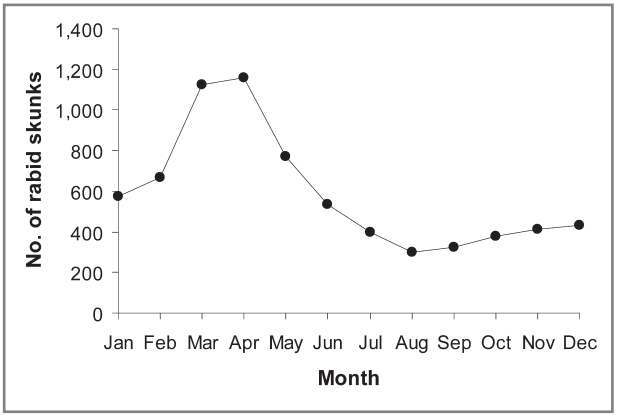

Figure 4—Cumulative monthly distribution of rabid skunks identified in Texas from 1985 through 2007.

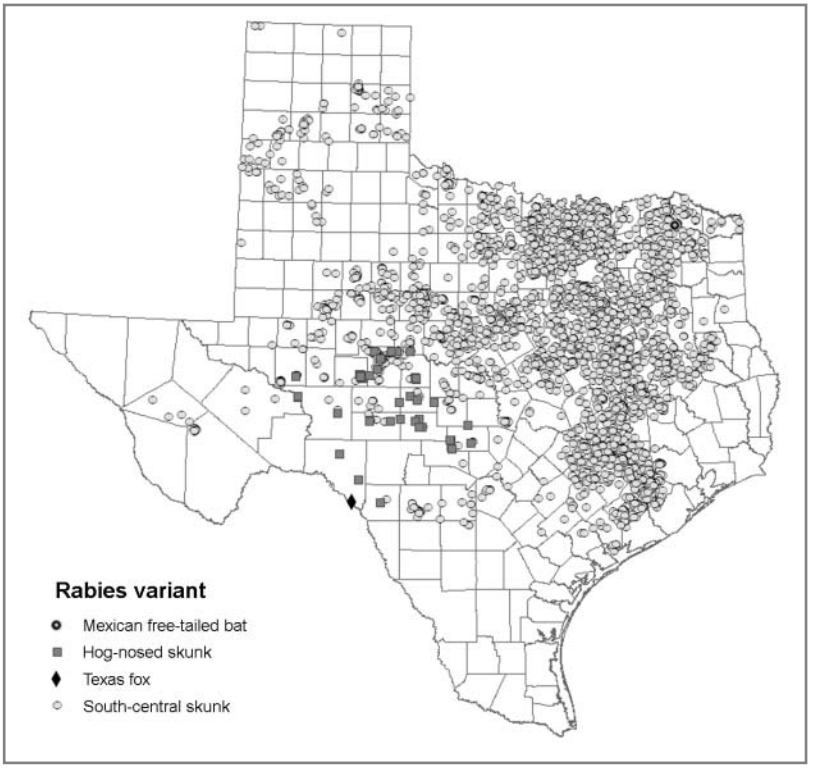

Figure 5—Rabies virus variants confirmed in rabid skunks identified in Texas from 1994 through 2007.

eastern part of the state was infected with the Mexican free-tailed bat variant of the rabies virus.

Exposure of domestic animals to rabid skunks— From 1987 through 2007, there were 11,705 domestic animals exposed to rabid skunks, with the number of exposed animals higher during years when more rabid skunks were identified (**Figure 6**). Similarly, the highest numbers of domestic animals were exposed to rabid skunks during March and April, the months during which the highest numbers of rabid skunks were identified. Of the 11,705 domestic animals exposed to rabid skunks, 10,197 (87.12%) were dogs and 1,315 (11.23%) were cats. Other animals that were exposed included horses, goats, cattle, pigs, wolf-dog hybrids, sheep, rabbits, and mules. Of the 11,705 animals exposed to rabid skunks, 3,888 (33.22%) were euthanatized. Most of the exposed animals that were euthanatized were puppies and kittens that had not yet been vaccinated against rabies. The remaining exposed animals were given postexposure rabies prophylaxis and confined in accordance with state law, depending on their rabies vaccination status.[2,7]

Exposure of humans to rabid skunks—From 1987 through 2007, there were 480 humans exposed to rabid skunks. As was the case for domestic animals exposed to rabid skunks, the number of exposed humans was higher during years when more rabid skunks were identified (Figure 6) and most humans were exposed during March or April.

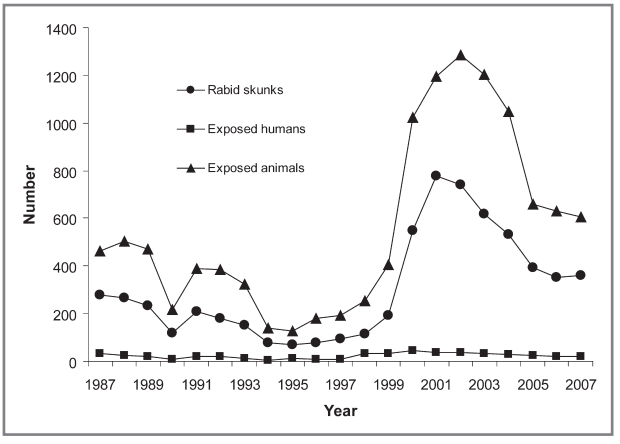

Figure 6—Numbers of humans and domestic animals exposed to rabid skunks in Texas from 1987 through 2007.

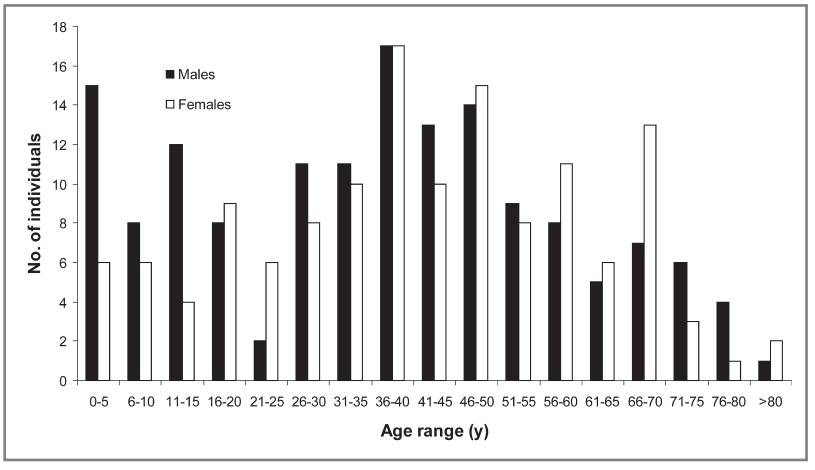

Figure 7—Age distribution of humans exposed to rabid skunks in Texas from 1987 through 2007.

There were 286 humans exposed to rabid skunks between 1987 and 2007 for which information on age was available; of these, 34 (11.89%) were between 36 and 40 years old, 23 (8.04%) were between 41 and 45 years old, and 29 (10.14%) were between 46 and 50 years old. Sixty-eight of the 286 (23.78%) exposed humans were ≤ 20 years old.

There were 300 humans exposed to rabid skunks between 1987 and 2007 for which information on gender was available; of these, 156 (52%) were males and 144 (48%) were females. For both males and females, the highest numbers of exposed individuals were between 36 and 40 years old (**Figure 7**). More of the individuals ≤ 20 years old who were exposed were male than female.

Most of the humans exposed to rabid skunks from 1987 through 2007 were exposed through some means other than a bite, with one of the most common methods of exposure being a person with a break in the skin petting or cleaning a dog that had been in a fight with a rabid skunk. For humans exposed to rabid skunks as a result of a bite, the most common location of the bite was the feet, followed by the arms and hands (generally occurring as a result of trying to separate a dog from a rabid skunk) and the face (most often occurring while the person was asleep). One person was exposed as a result of a bite to the buttocks while the individual was crawling under a mobile home.

When information recorded by case investigators on the behavior of rabid skunks that had exposed humans to rabies virus was examined, the most commonly reported behaviors were attacking dogs, appearing outside during the day, attacking humans, entering a dog pen, approaching or entering a house, acting sick, attacking a cat or other animal, and entering a tent. A review of behaviors of all 362 skunks confirmed to be rabid during 2007, regardless of human exposure, revealed that the most frequent behaviors were entering a dog pen (148 incidents), appearing outside during the day (140 incidents), and attacking pets (64 incidents). Multiple behaviors could be exhibited by a single rabid skunk.

Discussion

An important limitation of the present study was that for a wide variety of reasons, many skunks infected with or suspected to be infected with rabies virus likely were not submitted for laboratory testing. For example, particularly in rural areas, it is possible that skunks that are killed at a residence or by a vehicle might have been disposed of, rather than submitted for testing, especially if there was no indication of exposure to humans or domestic animals. As a result, findings in the present study probably underreport the number of rabid skunks in Texas during the study period. In addition, data for earlier years of the study were limited by the amount of information recorded during case investigations. In general, the amount and type of information recorded increased as the years progressed.

In the present study, it was found that the numbers of domestic animals and

humans exposed to rabid skunks generally increased as the number of rabid skunks increased, emphasizing the public health implications of rabies in skunks. Important economic concerns related to rabid skunks include the cost of confining and observing exposed domestic animals, the costs of postexposure prophylaxis in exposed humans and animals, and the costs associated with further preventing disease transmission.

The number of rabid skunks peaked during 1961, 1979, and 2001 in the present study, suggesting an approximate 20-year cycle for epizootic rabies in skunks. The increase in percentage of rabid skunks from urban areas, and the concomitant decrease in percentage of skunks from rural areas, may indicate greater opportunity for interactions between rabid skunks and humans or pets.

From 1985 through 2007 in the present study, the highest numbers of rabid skunks occurred during March and April, which corresponds with national data reported for 2006.[8] Home ranges of male skunks are substantially greater during the breeding season, which is February and March for striped, hooded, and hog-nosed skunks; March and April for eastern spotted skunks; and September and October for western spotted skunks.[6,9,b] The incubation period for clinical rabies in skunks is typically 1 to 2 months; therefore, it seems likely that increased travel and social interactions during the breeding season account for the peak in numbers of rabid skunks during March and April.[10] The second, smaller peak in case numbers from October through December could reflect the effects of increased movement and social interactions as young skunks disperse and attempt to establish their own home ranges, in that the dispersal time for all 5 species of skunks in Texas is late summer through September.[6,9,b] Movement of western spotted skunks during their breeding season in September and October could also have contributed to this increase in the number of cases during October through December, but with the decrease in the overall numbers of this species, any impact it had would likely have been negligible. Given that the numbers of exposed humans and domestic animals increased as the number of rabid skunks increased, it might be beneficial to increase rabies prevention education efforts during early spring and late fall when the population of rabid skunks is likely to be elevated.

Knowledge of the typical behaviors of rabid skunks may help when educating the public on how to recognize and avoid potentially affected animals. Healthy skunks are typically nocturnal and afraid of humans and their pets, whereas rabid skunks in the present study were frequently reported to be aggressive and active during the day.

In the present study, most of the domestic animals exposed to rabid skunks were dogs and cats. According to the Texas Administrative Code, domestic animals that have been exposed to a rabid animal must either be euthanatized or provided postexposure prophylaxis. For an animal that is not currently vaccinated against rabies, postexposure prophylaxis consists of immediate vaccination, confinement for 90 days, and booster vaccinations during the third and eighth weeks of confinement. For an animal that is currently vaccinated, postexposure prophylaxis consists of immediate vaccination and confinement for 45 days.[2,7]

On average, the largest proportions of humans exposed to rabid skunks in the present study were between 36 and 50 years old. Males overall did not appear more likely to be exposed than females, but young males were more likely to be exposed than young females. Most often, exposure in humans did not involve a bite. For humans exposed to rabid skunks as a result of a bite, a frequent location of the bite was the feet, which could potentially have been related to the fact that skunks, being about the size of a domestic cat, have easy access to the feet of humans. Alternatively, it is possible that people would be prone to use their feet to defend themselves against attacks by rabid skunks.

Orally administered rabies vaccines have generally not been successful in controlling rabies in skunks because baits used for oral rabies vaccination programs in other species have not been well accepted.[11] There is also limited research concerning the efficacy of existing oral rabies vaccines in skunks.[12,13] Studies of new bait options, biomarkers, and vaccine efficacy are ongoing, but substantial increases in bait acceptability and vaccine efficacy are required before an oral rabies vaccination program for skunks can be viable.

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