

Public Veterinary Medicine: Public Health

Rabies surveillance in the United States during 2004

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Summary—During 2004, 49 states and Puerto Rico reported 6,836 cases of rabies in nonhuman animals and 8 cases in human beings to the CDC, representing a 4.6% decrease from the 7,170 cases in nonhuman animals and 3 cases in human beings reported in 2003. Approximately 92% of the cases were in wildlife, and 8% were in domestic animals (compared with 91% and 9%, respectively, in 2003). Relative contributions by the major animal groups were as follows: 2,564 raccoons (37.5%), 1,856 skunks (27.1%), 1,361 bats (19.9%), 389 foxes (5.7%), 281 cats (4.1%), 115 cattle (1.7%), and 94 dogs (1.4%). Compared with the numbers of reported cases in 2003, cases in 2004 decreased among all groups, except bats, cattle, human beings, and “other domestics” (1 llama). Decreases in numbers of rabid raccoons during 2004 were reported by 12 of the 20 eastern states in which raccoon rabies was enzootic. In the East, Massachusetts reported the first cases of raccoon rabies detected beyond the Cape Cod oral rabies vaccine barrier. Along the western edge of the raccoon rabies epizootic (Ohio in the north and Tennessee in the south), cases of rabies were reported from unexpected new foci beyond oral rabies vaccine zones.

On a national level, the number of rabies cases in skunks during 2004 decreased by 12.1% from the number reported in 2003. Once again, Texas reported the greatest number ($n = 534$) of rabid skunks and the greatest overall state total of rabies cases (913). Texas reported only 1 case of rabies in a dog that was infected with the dog/coyote rabies virus variant and only 22 cases associated with the Texas gray fox rabies virus variant (compared with 61 cases in 2003). The total number of cases of rabies reported nationally in foxes and raccoons declined 14.7% and 2.7%, respectively, during 2004. The 1,361 cases of rabies reported in bats during 2004 represented a 12.3% increase over the previous year's total of 1,212 cases for this group of mammals. Cases of rabies reported in cats, dogs, horses and mules, and sheep and goats decreased 12.5%, 19.7%, 31.8%, and 16.7%, respectively, whereas cases reported in cattle increased 17.4%. In Puerto Rico, reported cases of rabies in mongooses decreased 4.1% and rabies in dogs (9 cases) remained unchanged from those reported in 2003.

Among the 8 cases of rabies in human beings, 1 person from Oklahoma and 3 from Texas died following receipt of infected organs and tissues from an Arkansas donor. In California, a person originally from El Salvador and, in Florida, a person originally from Haiti both died of canine rabies infections acquired outside the United States. In Wisconsin, a teenager contracted rabies from a bat bite and became the first known person to survive rabies despite not having received rabies vaccine prior to symptom onset.

In the United States and other developed nations, rabies is primarily a disease that affects and is maintained by wildlife populations (Figure 1). During 2004, wild animals accounted for almost 92% of all cases of rabies reported to the CDC. The most frequently reported rabid wildlife remain raccoons, skunks, bats, and foxes; however, the relative contributions of those species have continued to change in recent decades because of fluctuations in epizootics of rabies among animals infected with several distinct rabies virus variants (Figure 2).¹

Rabies control programs, including extensive vaccination campaigns, implemented during the 1940s and 1950s caused a substantial decline of rabies in domestic animals in the United States and all but eliminated the circulation of canine variants of the rabies virus in dogs (*Canis lupus*, formerly known as *Canis familiaris*) by the 1960s. Programs initiated to interrupt transmission of a canine variant that reemerged in south Texas during the late 1970s and early 1980s and recent cooperation with Mexico via the Border

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Infectious Disease Surveillance project have probably eliminated this variant, which has historically been maintained in coyotes (*Canis latrans*) and transmitted to unvaccinated dogs.²⁻⁵ Cases of rabies associated with a second canine rabies virus variant found mainly in gray foxes (*Urocyon cinereoargenteus*) in west and central Texas have been similarly reduced. Regulations now in place in Texas and other states that prohibit translocation of certain wild animal species for hunting and other restocking purposes have reduced the likelihood of accidental introductions of rabies virus variants into unaffected areas.^{1,6,7}

Various public health activities, including vaccination of domestic livestock and companion animals, vaccination programs targeting wildlife, and ongoing education programs, have contributed to the reduction in transmission of rabies virus from terrestrial animals to human beings.⁸ However, a number of rabies cases in human beings has resulted from infection with rabies virus variants that are associated with bats,^{9,10} a wildlife group difficult to target for rabies control by conventional methods. Prevention of rabies resulting from infection with bat-associated variants is further challenged by the frequent absence of known exposure histories involving a bat bite in human rabies cases. Since 2000, 14 of 15 cases of indigenously acquired rabies in human beings were associated, as determined by genetic analysis, with

rabies virus variants maintained by bats. Only 3 of these cases involved a report of a definite history of bat bite (4 received transplants from a rabies virus-infected donor).^{6,10} The most likely route of infection with rabies virus (excluding inoculation via infected transplant materials) remains transmission by a bite that either was unnoticed or ignored (and subsequently forgotten) during a seemingly insignificant interaction with a bat.

Rabies infections of terrestrial animals in most areas of the United States occur in geographically definable regions where virus transmission is primarily between members of the same species. Spillover infection from these species to other animal species occurs but rarely initiates sustained intraspecific transmission. Once established, virus transmission within a species can persist enzootically for decades or longer.

Rabies virus variants can be identified by reaction with panels of monoclonal antibodies¹¹ or by patterns of nucleotide substitution determined by genetic analysis.^{1,12} The spatial boundaries of enzootic rabies in reservoir species are temporally dynamic (Figure 3). Affected areas may expand and contract through virus transmission and population interactions.^{13,14} Population increases and emigration result in expansion of rabies-infected areas, whereas natural barriers, such as mountain ranges and bodies of water, that restrict animal movements or result in low population densities can slow the spread of rabies. Unusual animal dispersal patterns and human-mediated translocation of infected animals have resulted in more rapid and unexpected introductions of rabies into new areas.^{1,6,7,12-14}

Raccoons (*Procyon lotor*) have been recognized as a reservoir for rabies in the southeastern United States since the 1950s. An outbreak that began during the late 1970s in the mid-Atlantic states was attributed to the translocation by humans of infected raccoons from the Southeast.¹⁵ Although identifiable as separate foci prior to 1994, the mid-Atlantic and southeastern foci have merged. Raccoon rabies is now enzootic in all of the eastern coastal states as well as Alabama, Ohio, Pennsylvania, Tennessee, Vermont, and West Virginia.

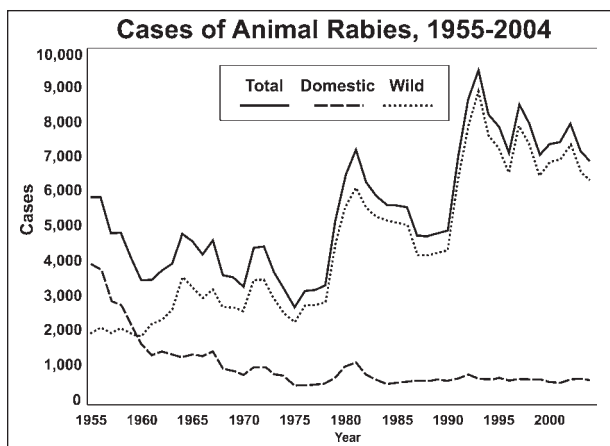


Figure 1—Cases of animal rabies in the United States, by year, 1955 to 2004.

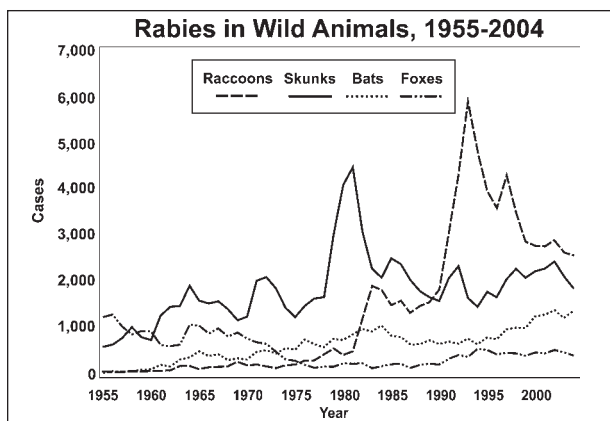


Figure 2—Cases of rabies in wild animals in the United States, by year and species, 1955 to 2004.

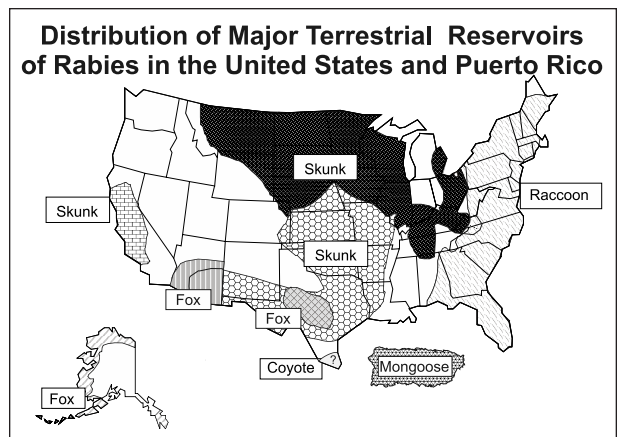


Figure 3—Distribution of major terrestrial reservoirs of rabies in the United States and Puerto Rico. Question mark indicates the lengthy absence of reports of infections with indigenously acquired dog/coyote rabies virus variant in the presence of active regional rabies surveillance, which suggests that the variant is no longer maintained by this wildlife reservoir in the United States.

Three different rabies virus variants are responsible for disease in skunks (primarily *Mephitis mephitis*) in California and the north central and south central states. In Alaska, a long-standing reservoir for rabies virus exists in red and arctic foxes (*Vulpes vulpes* and *Alopex lagopus*, respectively). Rabies spread during the 1950s to affect foxes across Canada and, intermittently, foxes in adjoining areas of the New England states. Rabies persists in foxes in Alaska, whereas reports of rabid foxes have declined in Canada. Two different rabies virus variants are present in geographically limited populations of gray foxes (*U cinereoargenteus*) in Arizona and Texas. Enzootic rabies among canids in southern Texas had been the result of long-standing interactions between unvaccinated domestic dogs and coyotes at the Texas-Mexico border^{2,5}; however, only 2 dogs (believed to have been translocated from outside the United States) have been reported infected with the dog/coyote rabies virus variant in Texas since 2001. On the island of Puerto Rico, another wildlife rabies reservoir exists in mongooses.^{16,17} Rabies virus maintained and circulated by mongooses is periodically transmitted to unvaccinated dogs that may, in turn, transmit the infection to human beings.⁶

Despite the threat of rabies transmission from wild terrestrial carnivores, the use of population-reduction programs to control rabies among such animals is not desirable. Programs in Europe and southeastern Canada have used modified-live or recombinant virus vaccines for oral immunization of free-ranging wildlife reservoir species to control the disease. During the past 2 decades, more than 100 million doses of vaccine-laden bait have been distributed over 6 million square kilometers in Europe,¹⁸ with promising results for controlling rabies in red foxes. The use of oral vaccination strategies in Switzerland during the past 20 years resulted in a declaration of rabies-free status for that country in 1998, and similar strategies in France led to a similar declaration by that country as of the end of 2000.¹⁹ Substantial decreases in the number of reported cases of rabies in fox populations in southern Ontario strongly support the observation that rabies virus associated with red foxes can be eliminated by vaccination. Distribution of an oral **vaccinia-rabies glycoprotein (V-RG)** recombinant vaccine targeting raccoons in the eastern United States²⁰⁻²² and gray foxes and coyotes in Texas⁵ has shown promise as a complement to traditional rabies control methods. Products used in oral vaccination programs are self-replicating, and the unintentional exposure of nontarget species, including human beings, must be minimized and monitored.^{23,24}

Overlaying the patterns of rabies virus maintenance among terrestrial mammals are multiple, independent reservoirs for rabies virus in several species of insectivorous bats. Rabies virus transmission among bats appears to be primarily intraspecific, and distinct virus variants can be identified for different bat species. In contrast to maintenance cycles in terrestrial animals, however, the greater mobility of bats precludes definitive range-mapping of different variants, other than as the geographic ranges of the implicated host bat species. Because bat species known to be reservoirs for

rabies virus are found in all areas of the continental United States, every state except Hawaii is considered enzootic for rabies. Although transmission of rabies virus from bats to terrestrial mammals occurs, there is little evidence that such transmission results in sustained, independent, intraspecific cycles among terrestrial animals. Genetic analysis indicates net differences of 15% to 20% between rabies virus RNA sequences in bats, compared with those in terrestrial mammals. Thus, instances of spillover transmission of rabies virus from bats are readily detectable, as would be sustained transmission of a bat-associated variant in a terrestrial mammal population.

This report is prepared annually to inform veterinarians and public health officials of the current status of rabies in the United States. Information is provided on the geographic distribution of rabies and long- and short-term temporal patterns for reported cases of rabies in various species. Long-term trends for reported cases of rabies in animals in the United States are generated by examining reports beginning with 1955. For this report, short-term trends were determined by comparing reported cases from 2004 with those from 2003 and by examining seasonal patterns for selected species.

Summaries of 2004 surveillance data are provided for Canada and Mexico because of common borders and frequent travel between the United States and these countries. A brief update on cases of rabies and other related activities reported to the CDC during 2005 is also included.

Collection of Data

Data collection procedures were similar to those described previously.⁶ Between January 1 and December 31, 2004, all 50 states, New York City, and Puerto Rico reported, on a monthly basis, the number of cases of rabies in animals to the CDC by county of origin and type of animal. States report cases among most terrestrial mammals using the common names of these animals (usually identifiable to the taxonomic level of genus and often to the level of species); however, bats are frequently reported only to the taxonomic level of order (ie, *Chiroptera* = bats). Several states reported data by use of the Public Health Laboratory Information System or the Laboratory Information Tracking System.^{25,26} All year-end totals were confirmed by facsimile transmission and telephone verification with state or territorial health department officials. Data from Canada were obtained from Dr. Carolyn Inch, Animal Health and Production Division, Canadian Food Inspection Agency, and data from Mexico were obtained from Dr. Oscar Velazquez Monroy, Director General del Centro de Vigilancia Epidemiologica, Secretaria de Salud, Mexico.

Diagnoses in animals suspected of having rabies were made by **direct immunofluorescent antibody (DFA)** staining of rabies viral antigen in brain material submitted to the state or local health departments. Virus isolation in neuroblastoma cell cultures or mice and nucleic acid detection via reverse transcriptase-polymerase chain reaction assays were used to confirm some cases.

Table 1—Cases of rabies in the United States, by state and category, during 2004.

| Rabies in the United States, 2004 | | | | | | | | | | | | | | | | | | | |
|-----------------------------------|------------------|------------|--------------|-----------|------------|------------|---------------|--------------|----------|-----------------|--------------|------------|--------------|-----------------|-------------------------|----------------|--------------|----------------|--------------|
| State (City) | Domestic animals | | | | | | | | | | Wild animals | | | | | | | Changes 2003 % | |
| | All animals | Domestic | Wild | Dogs | Cats | Cattle | Horses/ mules | Sheep/ goats | Swine | Other domestic* | Skunks | Foxes | Bats | Raccoons | Rodents and lagomorphs† | Other wild‡ | Human beings | | |
| AL | 66 | 5 | 61 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 1 | 23 | 36 | 0 | 1 ^m | 0 | 68 | -2.94 | |
| AK | 11 | 2 | 9 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 9 | 22.22 | |
| AZ | 120 | 0 | 120 | 0 | 0 | 0 | 0 | 0 | 0 | 24 | 17 | 75 | 0 | 0 | 4 ⁿ | 0 | 75 | 60.00 | |
| AR | 55 | 6 | 48 | 5 | 0 | 0 | 1 | 0 | 0 | 32 | 1 | 15 | 0 | 0 | 0 | 1 | 69 | -20.29 | |
| CA | 184 | 2 | 181 | 0 | 2 | 0 | 0 | 0 | 0 | 25 | 5 | 150 | 0 | 0 | 1 ^p | 1 | 218 | -15.60 | |
| CO | 47 | 0 | 47 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 47 | 0 | 0 | 0 | 0 | 43 | 9.30 | |
| CT | 223 | 7 | 216 | 0 | 5 | 1 | 0 | 1 | 0 | 54 | 2 | 23 | 134 | 3 ^q | 0 | 0 | 188 | 18.62 | |
| DC | 32 | 4 | 28 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 1 | 15 | 12 | 0 | 0 | 0 | 5 | 540.00 | |
| DE | 59 | 10 | 49 | 1 | 9 | 0 | 0 | 0 | 0 | 5 | 5 | 2 | 37 | 0 | 0 | 0 | 65 | -9.23 | |
| FL | 204 | 9 | 194 | 1 | 8 | 0 | 0 | 0 | 0 | 1 | 29 | 20 | 142 | 0 | 2 ^r | 1 | 193 | 5.70 | |
| GA | 344 | 19 | 325 | 4 | 9 | 3 | 2 | 0 | 0 | 1 ^s | 38 | 35 | 19 | 227 | 0 | 6 ^t | 0 | 402 | -14.43 |
| HI | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | — | |
| ID | 8 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 7 | 0 | 0 | 0 | 0 | 15 | -46.67 | |
| IL | 51 | 1 | 50 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 50 | 0 | 0 | 0 | 0 | 24 | 112.50 | |
| IN | 12 | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 11 | 0 | 0 | 0 | 0 | 31 | -61.29 | |
| IA | 100 | 24 | 76 | 3 | 11 | 10 | 0 | 0 | 0 | 28 | 1 | 47 | 0 | 0 | 0 | 0 | 106 | -5.66 | |
| KS | 99 | 24 | 75 | 2 | 13 | 7 | 2 | 0 | 0 | 69 | 2 | 4 | 0 | 0 | 0 | 0 | 166 | -40.36 | |
| KY | 23 | 2 | 21 | 1 | 0 | 0 | 1 | 0 | 0 | 14 | 0 | 7 | 0 | 0 | 0 | 0 | 39 | -41.03 | |
| LA | 4 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 4 | 0.00 | |
| ME | 69 | 1 | 68 | 0 | 1 | 0 | 0 | 0 | 0 | 29 | 4 | 7 | 26 | 2 ^u | 0 | 0 | 82 | -15.85 | |
| MD | 336 | 16 | 320 | 1 | 13 | 2 | 0 | 0 | 0 | 22 | 24 | 23 | 244 | 6 ^v | 1 ^w | 0 | 371 | -9.43 | |
| MA | 325 | 10 | 315 | 1 | 7 | 2 | 0 | 0 | 0 | 99 | 11 | 34 | 169 | 2 ^x | 0 | 0 | 216 | 50.46 | |
| MI | 42 | 1 | 41 | 1 | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 37 | 0 | 0 | 0 | 0 | 48 | -12.50 | |
| MN | 94 | 17 | 77 | 6 | 1 | 8 | 1 | 1 | 0 | 58 | 0 | 19 | 0 | 0 | 0 | 0 | 48 | 95.83 | |
| MS | 11 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 4 | 175.00 | |
| MO | 59 | 2 | 57 | 1 | 0 | 0 | 0 | 1 | 0 | 19 | 0 | 38 | 0 | 0 | 0 | 0 | 43 | 37.21 | |
| MT | 26 | 3 | 23 | 0 | 1 | 0 | 2 | 0 | 0 | 8 | 0 | 15 | 0 | 0 | 0 | 0 | 22 | 18.18 | |
| NE | 104 | 30 | 74 | 3 | 7 | 13 | 6 | 1 | 0 | 64 | 4 | 6 | 0 | 0 | 0 | 0 | 99 | 5.05 | |
| NV | 8 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 0 | 6 | 33.33 | |
| NH | 32 | 1 | 31 | 0 | 0 | 1 | 0 | 0 | 0 | 17 | 2 | 4 | 8 | 0 | 0 | 0 | 29 | 10.34 | |
| NJ | 210 | 16 | 194 | 0 | 14 | 1 | 1 | 0 | 0 | 16 | 3 | 47 | 127 | 0 | 1 ^y | 0 | 248 | -15.32 | |
| NM | 6 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 5 | 0 | 0 | 0 | 0 | 7 | -14.29 | |
| NY | 533 | 22 | 511 | 1 | 19 | 2 | 0 | 0 | 0 | 103 | 30 | 115 | 253 | 5 ^z | 5 ^z | 0 | 423 | 26.00 | |
| NYC | 14 | 0 | 14 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 10 | 0 | 0 | 0 | 6 | 133.33 | |
| NC | 659 | 47 | 612 | 10 | 29 | 7 | 1 | 0 | 0 | 120 | 74 | 29 | 386 | 0 | 3 ^{aa} | 0 | 769 | -14.30 | |
| ND | 75 | 23 | 52 | 3 | 9 | 7 | 4 | 0 | 0 | 49 | 0 | 2 | 1 | 0 | 0 | 0 | 57 | 31.58 | |
| OH | 77 | 1 | 76 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 30 | 45 | 0 | 0 | 0 | 53 | 45.28 | |
| OK | 114 | 28 | 85 | 6 | 8 | 9 | 3 | 2 | 0 | 80 | 1 | 3 | 0 | 0 | 1 ^{ab} | 1 | 204 | -44.12 | |
| OR | 7 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 7 | 0.00 | |
| PA | 415 | 45 | 370 | 1 | 39 | 5 | 0 | 0 | 0 | 63 | 22 | 37 | 237 | 6 ^{ac} | 5 ^{ad} | 0 | 429 | -3.26 | |
| PR | 63 | 16 | 47 | 9 | 5 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 47 ^{ae} | 0 | 71 | -11.27 | |
| RI | 45 | 3 | 42 | 0 | 3 | 0 | 0 | 0 | 0 | 28 | 0 | 5 | 9 | 0 | 0 | 0 | 71 | -36.62 | |
| SC | 181 | 5 | 176 | 2 | 3 | 0 | 0 | 0 | 0 | 32 | 21 | 11 | 111 | 0 | 1 ^{af} | 0 | 276 | -34.42 | |
| SD | 94 | 22 | 72 | 3 | 5 | 11 | 3 | 0 | 0 | 67 | 0 | 4 | 0 | 1 ^{ag} | 0 | 0 | 132 | -28.79 | |
| TN | 52 | 1 | 51 | 1 | 0 | 0 | 0 | 0 | 0 | 27 | 1 | 11 | 11 | 0 | 1 ^{ah} | 0 | 103 | -49.51 | |
| TX | 913 | 70 | 840 | 19 | 22 | 13 | 12 | 4 | 0 | 534 | 16 | 269 | 12 | 0 | 9 ^{ba} | 3 | 909 | 0.44 | |
| UT | 7 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 14 | -50.00 | |
| VT | 45 | 0 | 45 | 0 | 0 | 0 | 0 | 0 | 0 | 21 | 7 | 1 | 15 | 1 ^{ib} | 0 | 0 | 38 | 18.42 | |
| VA | 474 | 38 | 436 | 3 | 25 | 10 | 0 | 0 | 0 | 89 | 56 | 17 | 267 | 5 ^{ic} | 2 ^{cc} | 0 | 543 | -12.71 | |
| WA | 20 | 0 | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 20 | 0 | 0 | 0 | 0 | 23 | -13.04 | |
| WV | 74 | 10 | 64 | 1 | 6 | 1 | 2 | 0 | 0 | 10 | 4 | 4 | 45 | 1 ^{id} | 0 | 0 | 83 | -10.84 | |
| WI | 10 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 8 | 0 | 0 | 0 | 1 | 14 | -28.57 | |
| WY | 8 | 1 | 7 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 5 | 0 | 0 | 0 | 0 | 5 | 60.00 | |
| Total | 6,844 | 544 | 6,292 | 94 | 281 | 115 | 43 | 10 | 0 | 1 | 1,856 | 389 | 1,361 | 2,564 | 32 | 90 | 8 | 7,173 | -4.59 |
| % 2004§ | 100.00 | 7.95 | 91.93 | 1.37 | 4.11 | 1.68 | 0.63 | 0.15 | 0.00 | 0.01 | 27.12 | 5.68 | 19.89 | 37.46 | 0.47 | 1.32 | 0.12 | | |
| Total 2003¶ | 7,173 | 614 | 6,556 | 117 | 321 | 98 | 63 | 12 | 2 | 1 | 2,112 | 456 | 1,212 | 2,635 | 38 | 103 | 3 | | |
| % Change# | -4.59 | -11.40 | -4.03 | -19.66 | -12.46 | 17.35 | -31.75 | -16.67 | -100.00 | 0.00 | -12.12 | -14.69 | 12.29 | -2.69 | -15.79 | -12.62 | 166.67 | | |

*Other domestic includes: ^a llama. †Rodents and lagomorphs include: ³ groundhogs; ² groundhogs; ¹ beaver, 5 groundhogs; ² groundhogs; ⁵ groundhogs; ⁵ groundhogs, 1 muskrat; ¹ groundhog; ¹ groundhog; ⁵ groundhogs; ¹ groundhog. ‡Other wild includes: ^m1 bobcat; ² bobcats, 2 coyotes; ⁿ1 opossum; ¹ bobcat, 1 otter; ⁵ bobcats, 1 coyote; ¹ deer; ¹ deer; ¹ coyote, 3 deer, 1 otter; ¹ coyote, 2 bobcats; ^o1 deer; ¹ bear, 1 bobcat, 3 deer; ⁴⁷ mongooses; ¹ bobcat; ^o1 opossum; ⁷ bobcats, 1 ringtail, 1 wolf-dog hybrid; ^o1 bobcat, 1 deer. §Percentage of all rabid animals in 2004. ¶Totals include 1 PR rabid dog reported by MA, 1 PR rabid mongoose reported by KS, and 1 rabid NY cat reported by MA and exclude 1 rabid dog from Thailand reported by CA. †2003 Total by species. #Percentage change from 2003.

Rabies in Wild Animals

Wild animals accounted for 6,292 (91.9%) of the 6,844 reported cases of rabies in 2004 (Figure 1); this number represents a 4% decrease from the 6,556 cases reported in 2003 (Table 1). Raccoons continued to be

the most frequently reported rabid wildlife species (37.5% of all animal cases during 2004), followed by skunks (27.1%), bats (19.9%), foxes (5.7%), and other wild animals, including rodents and lagomorphs (1.8%). Numbers of reported cases in foxes, skunks,

and raccoons decreased 14.7%, 12.1%, and 2.7%, respectively, from 2003 totals, whereas those in bats increased by 12.3%.

Raccoons—The 2,564 cases of rabies in raccoons (*P. lotor*) reported in 2004 were a 6-year low for this species (Figures 2 and 4). Decreases in numbers of rabid raccoons during 2004 were reported by 12 of the 20 eastern states in which raccoon rabies was enzootic, including Delaware (5.1% decrease; 39 cases in 2003 to 37 in 2004), Georgia (6.2%; 242 to 227), Maine (29.7%; 37 to 26), Maryland (9.3%; 269 to 244), New Hampshire (27.3%; 11 to 8), New Jersey (3.1%; 131 to 127), North Carolina (25.5%; 518 to 386), Rhode Island (60.9%; 23 to 9), South Carolina (32.7%; 165 to 111), Vermont (21.1%; 19 to 15), Virginia (16.8%; 321 to 267), and West Virginia (11.8%; 51 to 45; Figures 4 and 5; Table 1).^{6,12-15,20,27} Six states with well-documented enzootic raccoon rabies reported increases in numbers of rabid raccoons, including Alabama (9.1% increase), Connecticut (19.6%), Florida (11.8%), Massachusetts (108.6%), New York (32.8%), and Pennsylvania (1.3%). Ohio reported an increase of 2,150% (45 cases reported in raccoons in 2004, compared with 2 in 2003), and Tennessee, which reported its first cases in 2003, reported an increase of 175% (11 cases in 2004, com-

pared with 4 in 2003). The District of Columbia and New York City reported increases of 200.0% and 233.3%, respectively, during 2004.

The states of the northeastern/mid-Atlantic focus of the epizootic, consisting of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, Virginia, and West Virginia as well as the District of Columbia and New York City, accounted for 63.9% (1,638 cases) of the 2,564 total rabies cases in raccoons in 2004. The southeastern states of Alabama, Florida, Georgia, North Carolina, South Carolina, and Tennessee reported 35.6% (913 cases) of the total cases in raccoons.

Ohio reported 45 cases of rabies in raccoons infected with the raccoon variant of the rabies virus; the cases were primarily from 2 counties (Geauga and Lake) that were beyond the oral rabies vaccine (ORV) application area. Tennessee reported 11 cases of raccoon rabies in raccoons, all from Hamilton County in the south central area of the state. Of 169 cases of rabies in raccoons reported by Massachusetts, 103 cases were reported from Barnstable County in eastern Massachusetts across the ORV zone. Cases in each of these states represent extensions of the raccoon rabies epizootic, and increases in cases of rabies were reported west of the Ohio River in the North, west of the Appalachian Ridge in Tennessee in the South during 2003, in south central Tennessee in 2004, and east of a previously uninfected area beyond the 10-year-old Cape Cod ORV zone in Massachusetts in 2004. North Dakota reported a single case of rabies in a raccoon infected with the north central skunk rabies virus variant. Rabid raccoons reported by Texas (12 cases) were the result of spillover infection with rabies virus other than that associated with raccoons (usually the gray fox variant or the south central skunk variant).

Skunks—The 1,856 reported cases of rabies in skunks (mainly *M. mephitis*) in 2004 represented a 12.1% decrease from the number reported in 2003 (Figure 6; Table 1). Twenty-two of 40 states and New York City reported decreased numbers, and decreases of $\geq 50\%$ from 2003 were reported by Louisiana (100%; 1 case in 2003 to 0 cases in 2004), New Mexico (50%;

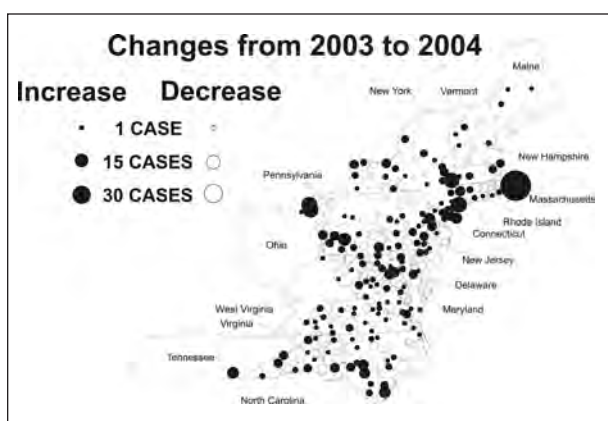


Figure 4—Changes in cases of rabies in raccoons in the mid-Atlantic and northeastern states, 2003 to 2004. Dot size is proportional to the number of cases in the county.

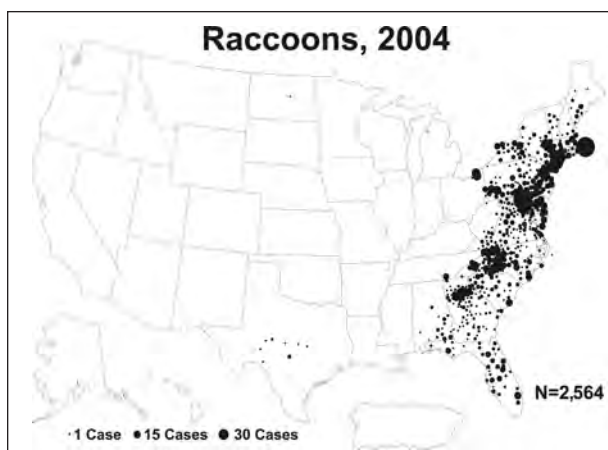


Figure 5—Reported cases of rabies in raccoons, by county, 2004.

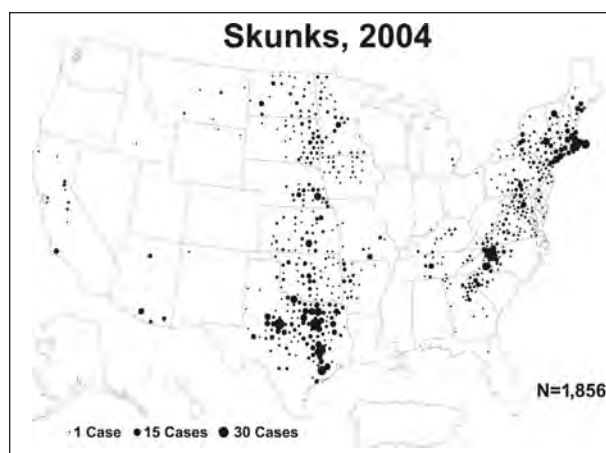


Figure 6—Reported cases of rabies in skunks, by county, 2004.

2 to 1), Tennessee (63.5%; 74 to 27), and New York City (66.7%; 3 to 1). Texas reported the greatest number of rabies cases in skunks (534; a 13.9% decrease from the 620 cases reported in 2003) and the greatest overall state total of rabies cases (913) during 2004. Eighteen states reported increases in numbers of rabid skunks in 2004. States that reported increases of > 100%, compared with cases reported in 2003, were Arizona (200%; from 8 cases to 24), Minnesota (152.2%; 23 to 58), Missouri (375%; 4 to 19), and New Hampshire (112.5%; 8 to 17). Louisiana reported 1 case in 2003 but did not report rabies in skunks during 2004. Florida, Idaho, Indiana, Ohio, and Wisconsin each reported a single case of rabies in a skunk in 2004 but did not report any rabid skunks in 2003. States in which the raccoon rabies virus variant is enzootic reported 41.8% (776/1,856) of the cases of rabies in skunks, the majority of which were presumably the result of spillover transmission of virus from raccoons. Rhode Island reported more rabid skunks (28 cases) than rabid raccoons (9) for an eighth consecutive year.

Bats—Rabies in bats accounted for 19.9% of all cases of rabies in animals reported in 2004 (Table 1). The 1,361 cases in 2004 represented an increase of 12.3% over those reported in 2003. Rabies in bats is widely distributed throughout the United States, with

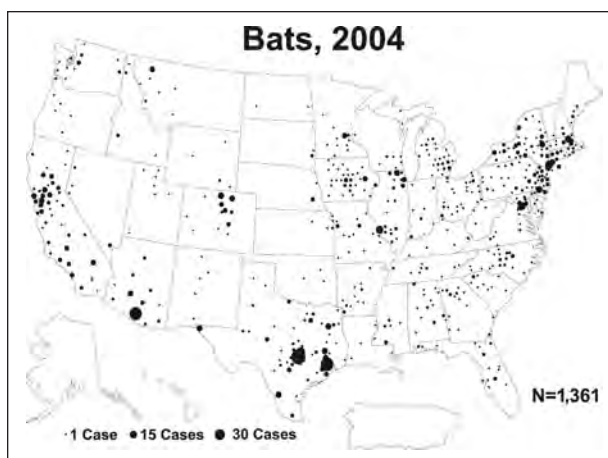


Figure 7—Reported cases of rabies in bats, by county, 2004.

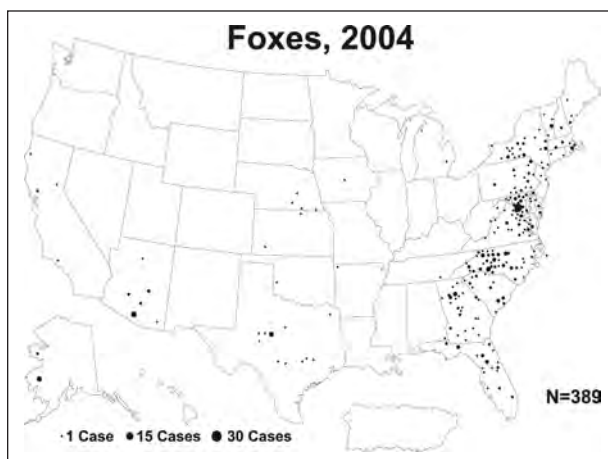


Figure 8—Reported cases of rabies in foxes, by county, 2004.

cases reported from all of the 48 contiguous states (Figure 7). During 2004, Texas reported the largest number of cases in bats (269), followed by California (150) and New York (118). Seven states (Colorado, Louisiana, Mississippi, Nevada, Oregon, Utah, and Washington) reported rabies in bats but not in terrestrial mammals. Alaska, Hawaii, and Puerto Rico did not report any cases of bat rabies.

Of the bats infected with the rabies virus, 40.1% (546/1,361) were identified beyond the taxonomic level of order (13 to genus, 533 to species). Among bats identified to species level, 61.2% (326/533) were *Eptesicus fuscus*, the big brown bat; 14.8% (79/533) were *Tadarida brasiliensis*, the Brazilian (Mexican) free-tailed bat; 4.5% (24/533) were *Pipistrellus hesperus*, the western pipistrelle; 4.3% (23/533) were *Myotis lucifugus*, the little brown bat; 3.6% (19/533) were *Lasiurus cinereus*, the hoary bat; 3.2% (17/533) were *Lasiurus borealis*, the red bat; 2.1% (11/533) were *Myotis californicus*, the California bat; 2.1% (11/533) were *Lasionycteris noctivagans*, the silver-haired bat; 0.9% (5/533) were *Lasiurus ega*, the southern yellow bat; 0.9% (5/533) were *Myotis yumanensis*, the Yuma bat; 0.6% (3/533) were *Antrozous pallidus*, the pallid bat; 0.6% (3/533) were *Lasiurus seminolus*, the Seminole bat; 0.6% (3/533) were *Pipistrellus subflavus*, the eastern pipistrelle; 0.4% (2/533) were *Myotis evotis*, the long-eared Myotis; 0.2% (1/533) were *Myotis austroriparius*, the southeastern Myotis; and 0.2% (1/533) were *Myotis thysanodes*, the fringed Myotis. Unspecified bats of the genus *Myotis* (13/546) accounted for the remaining rabid bats and contributed 2.4% to the total of bats identified beyond the taxonomic level of order. Not all states were able to speciate bats, nor did all states report total numbers of bats tested for rabies.

Foxes—Foxes (mainly *V vulpes*) accounted for 5.7% of all cases of rabies in animals reported in 2004 (Table 1). The 389 cases of rabies in foxes represented a 14.7% decrease from 2003, and most (332) were reported by states affected by the raccoon rabies virus variant (Figure 8). Georgia (35 cases), Maryland (24), South Carolina (21), and Texas (16) reported decreases

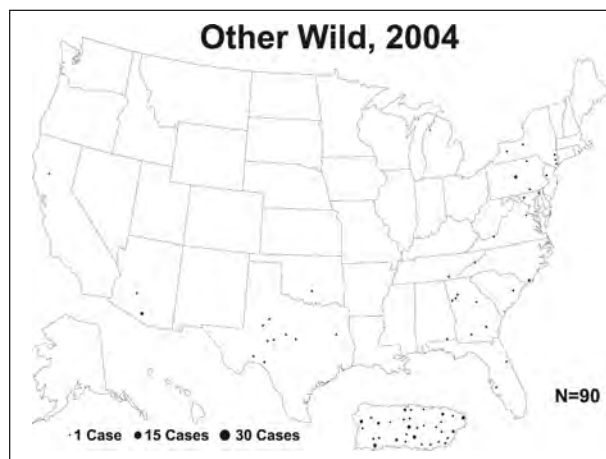


Figure 9—Reported cases of rabies in "Other wild" category of Table 1, by county and municipio (Puerto Rico), 2004.

of 8, 13, 25, and 12 cases, respectively, from 2003. New York (30 cases) and Virginia (56) reported increases of 11 and 8 cases, respectively, over 2003. Most cases of rabies in foxes reported by eastern states were probably caused by the raccoon rabies virus variant. Rabies in gray foxes in Arizona and Texas is usually (as determined by antigenic typing and genetic analysis) the result of infection with gray fox variants unique to independent gray fox reservoirs in each of those states. Kentucky (4 cases), Ohio (2), Oregon (1), Rhode Island (5), and South Dakota (1) reported rabid foxes in 2003 but did not report any in 2004. Arkansas (1 case), Iowa (1), Michigan (1), Oklahoma (1), Vermont (7), and the District of Columbia (1) reported rabid foxes in 2004 but not in 2003. Kansas (2 cases) reported no change in the number of rabid foxes reported in 2004, compared with those reported in 2003.

Other wild animals—Puerto Rico reported 47 rabid mongooses (*Herpestes javanicus*) during 2004, a 4.1% decrease from the 49 cases reported in 2003 (Figure 9). Other wildlife in which rabies was reported included 21 bobcats (*Lynx rufus*), 30 groundhogs (*Marmota monax*), 10 white-tail deer (*Odocoileus virginianus*), 5 coyotes (*C latrans*), 2 opossums (*Didelphis*

virginiana), 2 river otters (*Lontra canadensis*), 1 black bear (*Ursus americanus*), 1 beaver (*Castor canadensis*), 1 ringtail (*Bassariscus astutus*), and 1 wolf-dog hybrid (*C lupus* wild-domestic cross).^{28,29} With the exception of 1 groundhog reported by South Dakota, all cases of rabies in rodents and lagomorphs were reported by states in which rabies is epizootic in raccoons.²⁹ No cases of rabies in coyotes associated with the dog/coyote variant of the rabies virus previously circulating in regions of south Texas were reported in 2004 (Table 1).

Rabies in Domestic Animals

Domestic species accounted for 8% of all rabid animals reported in the United States in 2004 (Table 1). The number of domestic animals reported rabid in 2004 (544) represented an 11.4% decrease from the total reported in 2003 (Figure 10). Cases of rabies reported in cats and dogs decreased 12.5% and 19.7%, respectively, compared with totals reported in 2003. Texas reported the largest number of rabid domestic animals (70 cases), followed by North Carolina (47), Pennsylvania (45), and Virginia (38).

Cats—Most (197) of the 281 cases of rabies in cats were reported from states in which the raccoon rabies

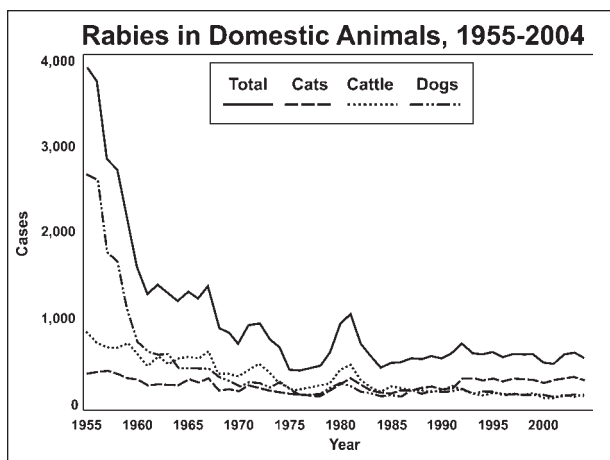


Figure 10—Cases of rabies in domestic animals in the United States, by year, 1955 to 2004.

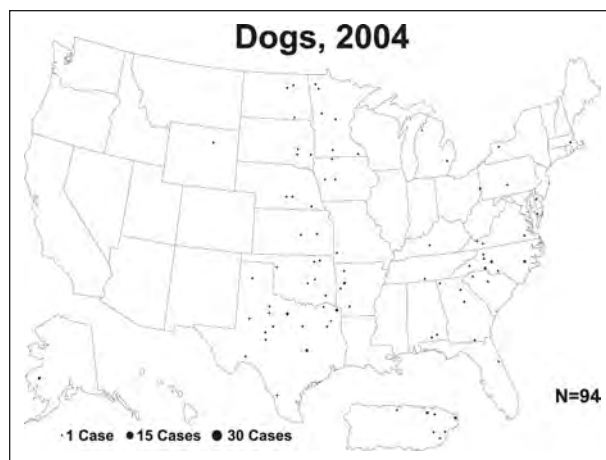


Figure 12—Reported cases of rabies in dogs, by county and municipio (Puerto Rico), 2004.

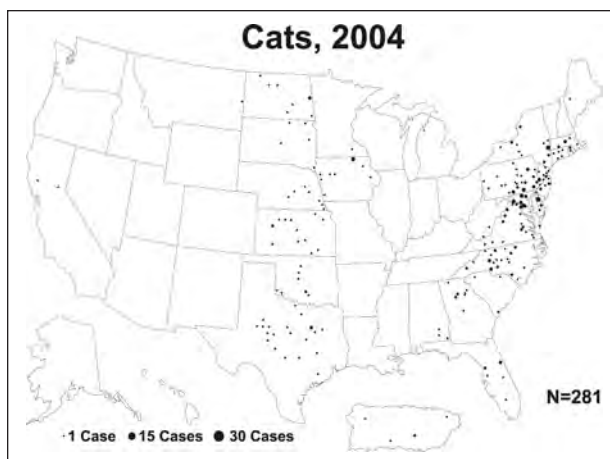


Figure 11—Reported cases of rabies in cats, by county and municipio (Puerto Rico), 2004.

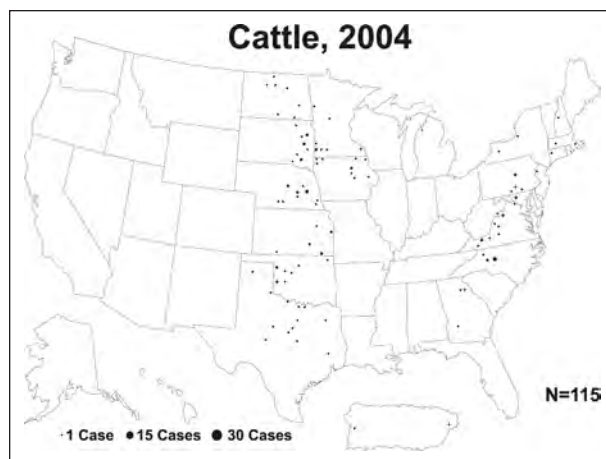


Figure 13—Reported cases of rabies in cattle, by county and municipio (Puerto Rico), 2004.

virus variant is present (Figure 11). Remaining cases were reported principally by Central Plains states, where most cases were presumably the result of spillover from rabid skunks or from rabid foxes in Texas. Nine states reported > 10 cases of rabies in cats (Pennsylvania, 39 cases; North Carolina, 29; Virginia, 25; Texas, 22; New York, 19; New Jersey, 14; Kansas, 13; Maryland, 13; and Iowa, 11). Twenty-four states and New York City did not report any rabid cats.

Dogs—Texas (19 cases), North Carolina (10), Puerto Rico (9), Minnesota (6), Oklahoma (6), Arkansas (5), and Georgia (4) reported the largest numbers of cases of rabies in dogs by individual states or territories. No other state reported > 3 cases of rabies in dogs in 2004. Massachusetts reported a rabid dog that had been translocated from Puerto Rico. One of the rabid dogs (believed to have been translocated) reported by Texas was infected with the dog/coyote rabies virus variant (the last case of rabies involving this variant was reported from this same border county [Webb] in February 2001, also in a dog translocated from Mexico) previously evident in south Texas (Figure 12; Table 1). Twenty-three states, the District of Columbia, and New York City did not report any rabid dogs.

Other domestic animals—The number of cases of rabies in cattle increased 17.4% from 98 in 2003 to 115 in 2004 (Figure 13; Table 1). Distribution of

rabid cattle was similar to that of rabid skunks in the central and midwestern states (Figures 6 and 13) and to rabid raccoons in the mid-Atlantic/northeastern region (Figures 5 and 13). Nebraska (13 cases), Texas (13), South Dakota (11), Iowa (10), Virginia (10), and Oklahoma (9) reported the largest numbers of rabid cattle. No other state reported > 8 cases of rabies in cattle in 2004. The 43 cases of rabies reported in horses and mules (including donkeys) in 2004 represented a 31.8% decrease from the 63 cases reported during 2003. Other reported cases of rabies in domestic animals included 1 llama, 6 goats, and 4 sheep.

Seasonal Trends

The frequency of reported cases of rabies in raccoons was bimodal, with a March-April peak and a slight decline to July. This was followed by a second higher August-September peak and a decline to a November-December low (Figure 14). The frequency of reporting for rabid skunks also showed a March-April peak, followed by a decline to a July summer low, with an increase to an August-November plateau, and a final decline into December. Reports of rabid bats increased from a January low through the spring and then more sharply during early summer months to a distinct peak in August, followed by a steep decline from September to December. Reports of rabid foxes increased only gradually from January through the spring and summer months, followed by a gradual decline to a November-December low.

Reported cases in cats rose from January to a spring peak in March, followed by an abrupt decline to an April low, before increasing to much higher peaks in June and September, prior to an autumn decline and then dropping sharply in December (Figure 15). Reports of rabies cases in dogs rose from a February-March low to an April-May high before declining to a July low. Reports then increased slightly through August to a September-November plateau before a final decline in December. Reported cases in cattle were somewhat elevated in January but declined in February, prior to rising to an April peak that led into an undulating summer decline to a September low. This was followed by a slight second increase in November, followed by a December decline.

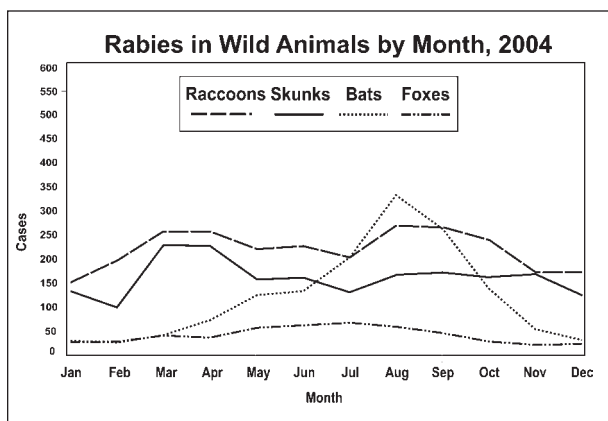


Figure 14—Cases of rabies in wild animals in the United States, by month, 2004.

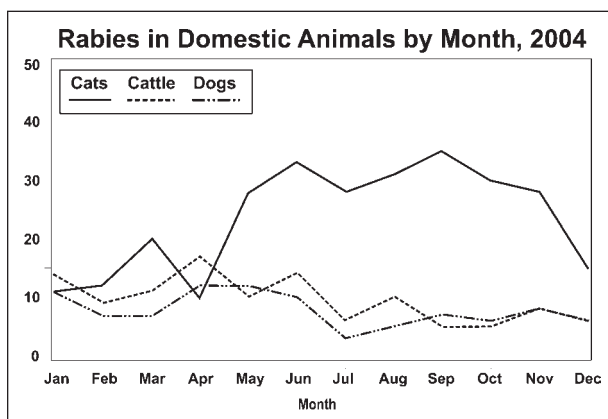


Figure 15—Cases of rabies in domestic animals in the United States, by month, 2004.

Rabies in Human Beings

Eight cases of rabies in human beings were reported in the United States during 2004 (Table 2).^{6,30-35} Two cases involved rabies infections that were acquired within the United States as a result of rabies exposures from bats, and 1 of these patients survived.^{34,35,a} The other patient did not survive, and because rabies was not immediately recognized as the cause of death, organs and tissues transplanted from that donor patient resulted in 4 additional rabies deaths in organ recipients.³¹⁻³³ The remaining 2 cases involved rabies infections that were acquired outside the United States in countries where canine rabies is enzootic.^{30,b}

On February 15, 2004, a 41-year-old man died of rabies following a brief course of illness and hospitalization in Broward County, Florida. Although rabies

was considered as a possible cause of the patient's death, antemortem samples were not obtained for testing. In March, rabies was confirmed in postmortem samples of fixed brain material that were sent to the CDC because of suspicious intracellular inclusions. Subsequent investigation and laboratory testing identified a canine rabies virus variant present in Haiti, where the man had traveled and reportedly had been bitten by a dog. This variant has not been documented among domestic or wild animal reservoirs in the United States.³⁰

During June and July 2004, the CDC confirmed diagnoses of rabies in 3 recipients of transplanted organs, 1 recipient of a transplanted arterial segment,

and in their common donor, who was found subsequently to have serologic evidence of rabies infection. The transplant recipients developed encephalitides of unknown etiologies following transplantation and subsequently died.

The organ donor was a 20-year-old man from Miller County, Arkansas, who visited a hospital with severe mental status changes and a low-grade fever. Neurologic imaging indicated findings consistent with a subarachnoid hemorrhage, which led to cerebral herniation and death on May 4, 2004.

Donor eligibility screening and testing did not reveal any contraindications to transplantation, and the patient's family agreed to organ donation. Lungs, kidneys, liver, and an arterial segment were recovered from the donor. The lungs were transplanted in an Alabama hospital into a patient who died of intraoperative complications. Four other recipients received transplants from this donor at a Texas transplant facility and later died; a liver recipient from Oklahoma died on May 27, a kidney recipient died on June 7, an arterial segment recipient died June 10, and another kidney recipient died on June 21. Examination of patient brain tissues at the CDC revealed encephalitis with viral inclusions suggestive of Negri bodies; the diagnosis of rabies in all 4 recipients was confirmed by immunohistochemical testing and by the detection of rabies virus antigen in fixed brain tissue by DFA tests. Antigenic typing of the virus was compatible with a rabies virus variant associated with bats. Further analysis demonstrated the variant involved to be that associated with *T brasiliensis*, Brazilian (Mexican) free-tailed bats. A friend of the donor indicated he had made mention of marks on his neck that he believed to be the result of bites from bats.³¹⁻³³

During September 2004, a 15-year-old girl from Fond du Lac County, Wisconsin, was bitten on the finger by a bat that she saw fall to the floor while attending a church service. She released the bat outdoors, so it was unavailable for rabies testing. Blood was visible at the site of her wound; it was cleaned with hydrogen peroxide, but medical attention was not sought, and rabies postexposure prophylaxis was not administered. Approximately 1 month following the bat bite, the girl complained of fatigue and of paraesthesia at the bite site. On her sixth day of illness, the history of the bat bite was reported, and rabies was considered in the differential diagnosis. Rabies virus-specific antibodies were detected in the patient's serum and CSF. Direct immunofluorescent antibody staining of nuchal skin biopsies was negative for viral antigen, and rabies virus was not isolated from saliva by cell culture. Her condition worsened, and her course of illness was managed with supportive care and neuroprotective measures that included a drug-induced coma, intubation, and ventilatory support. Following more than a month of illness, she was extubated and eventually transferred to a rehabilitation unit. Her recovery has been lengthy but continuous, with steady improvement to the present time.³ She is the first patient to develop and recover from rabies without receiving rabies prophylaxis either before or after illness onset. Five previous patients who survived were either previously vaccinated or received

Table 2—Cases of rabies in human beings in the United States and Puerto Rico, 2000 through September 2005,* by circumstances of exposure and rabies virus variant.

| Date of death | State of residence | Exposure history† | Rabies virus variant‡ |
|---------------|--------------------|-------------------------------|---------------------------|
| 20 Sep 00 | CA | Unknown§ | Bat, Tb |
| 9 Oct 00 | NY | Bite-Ghana | Dog, Africa |
| 10 Oct 00 | GA | Unknown§ | Bat, Tb |
| 25 Oct 00 | MN | Bite | Bat, Ln/Ps |
| 1 Nov 00 | WI | Unknown§ | Bat, Ln/Ps |
| 4 Feb 01 | CA | Unknown§-Philippines | Dog, Philippines |
| 31 Mar 02 | CA | Unknown§ | Bat, Tb |
| 31 Aug 02 | TN | Unknown§ | Bat, Ln/Ps |
| 28 Sep 02 | IA | Unknown§ | Bat, Ln/Ps |
| 10 Mar 03 | VA | Unknown§ | Raccoon, eastern US |
| 5 Jun 03 | PR | Bite | Dog/mongoose, Puerto Rico |
| 14 Sep 03 | CA | Bite | Bat, Ln/Ps |
| 15 Feb 04 | FL | Bite | Dog, Haiti |
| 4 May 04 | AR | Bite§ (organ donor) | Bat, Tb |
| 27 May 04 | OK | Liver transplant recipient | Bat, Tb |
| 7 Jun 04 | TX | Kidney transplant recipient | Bat, Tb |
| 10 Jun 04 | TX | Arterial transplant recipient | Bat, Tb |
| 21 Jun 04 | TX | Kidney transplant recipient | Bat, Tb |
| Survived 04 | WI | Bite | Bat, unknown |
| 26 Oct 04 | CA | Unknown§ | Dog, El Salvador |
| 27 Sep 05 | MS | Under investigation | Under investigation |

*All laboratory-confirmed cases of rabies in human beings who developed the disease in the United States and Puerto Rico, 2000 through September 2005. †Data for exposure history are reported only when the biting animal was available and tested positive for rabies, or when plausible information was reported directly by the patient (if lucid or credible), or when a reliable account of an incident consistent with rabies exposure (eg, dog bite) was reported by an independent witness (usually a family member). ‡Variants of the rabies virus associated with terrestrial animals in the United States and Puerto Rico are identified with the names of the reservoir animal (dog or dog/mongoose in all cases shown), followed by the name of the most definitive geographic entity (usually the country) from which the variant has been identified. Variants of the rabies virus associated with bats are identified with the names of the species of bats in which they have been found to be circulating. Because information regarding the location of the exposure and the identity of the exposing animal is almost always retrospective and much information is frequently unavailable, the location of the exposure and the identity of the animal responsible for the infection are often limited to deduction. §In some instances where the exposure history is unknown, there may have been known or inferred interaction that, especially for bats, could have involved an unrecognized bite.

Ln/Ps = *Lasiurus noctivagans* or *Pipistrellus subflavus*, the silver-haired bat or the eastern pipistrelle. Tb = *Tadarida brasiliensis*, the Brazilian (Mexican) free-tailed bat.

some form of postexposure prophylaxis before the onset of illness.^{34,35}

On October 19, 2004, a 22-year-old man, who was born in El Salvador and had been in Los Angeles County, California, for 15 months, developed nausea, vomiting, and right lower back pain. On October 21, he was admitted to a Los Angeles hospital and found to have kidney stones. However, his condition worsened, and on October 26, the patient had cardiopulmonary arrest and died. On January 21, 2005, a report made during examination of postmortem specimens by the coroner's office indicated that pathology findings for brain tissue from the patient were highly suspicious for rabies. Additional specimens were sent to the CDC for rabies testing. On January 25, the CDC confirmed the diagnosis of rabies by the DFA test on brain tissue. Interviews with local household contacts and family members in El Salvador revealed no travel or history of animal bites or exposures. Further analysis of samples from the patient demonstrated a sequence of the rabies virus that was compatible with a canine rabies virus variant present in El Salvador. This variant has not been documented among domestic or wild animal reservoirs in the United States.^b

Rabies in Canada and Mexico

Canada reported 254 laboratory-confirmed and 7 clinically diagnosed cases of rabies in domestic and wild animals in 2004. The 254 confirmed rabies cases reported in 2004 were a 3.8% decrease from the 264 confirmed cases reported in 2003. Eighty-seven percent of confirmed cases were in wild animals, 9.5% in domestic livestock, and 3.5% in domestic companion species. The decrease was attributable to fewer reported cases of rabies in bats, foxes (*V vulpes* and *A lagopus*), and raccoons (*P lotor*), which accounted for 32.7%, 5.5%, and 2%, respectively, of confirmed rabid animals reported in 2004. Reported cases in bats decreased 27.8% (83 cases in 2004, compared with 115 in 2003), cases of rabies in foxes decreased 50% (14 in 2004, compared with 28 in 2003), and cases of rabies in raccoons decreased 68.8% (5 in 2004, compared with 16 in 2003). Skunks (*M mephitis*) accounted for 45.7% of reported animals in 2004. In contrast to decreases in the other wildlife species, cases of rabies in skunks in Canada increased 52.6% (116 in 2004, compared with 76 in 2003). Most of the cases responsible for the increase in skunks were reported from the province of Manitoba. Ontario was the only province that reported cases infected with the raccoon rabies virus variant in 2004. Since the first detection of that variant in Ontario in 1999, a total of 195 infected raccoons have been reported by the Canadian Food Inspection Agency Laboratory.³⁶ Other notable contributions to the 2004 Canadian total included cats (< 1%), dogs (2.8%), equids (2.4%), goats (< 1%), and wolves (*C lupus*; 1%). Canada did not report any cases of rabies in human beings during 2004.³⁷

Mexico reported 264 laboratory-confirmed cases of rabies in domestic and wild animals during 2004. This represented a decrease of 20% from the 330 cases reported in 2003. Dogs accounted for 17% (45/264) of reported cases of rabies, a decrease of 40% from 2003

(75 cases). The other reported rabid animals included 186 cattle (70.5%), 9 equids, 8 bats, 5 sheep, 3 cats, 2 skunks (species unknown), 1 badger (*Taxidea taxus*), 1 deer (species unknown), 1 fox (species unknown), 1 goat, 1 swine, and 1 wild cat (presumably a bobcat [*L rufus*]). Three cases of rabies were reported in human beings in 2004, compared with 1 case in 2003. Bats were implicated as the source animals in the exposures of 2 of these cases, and a cat was the source of the remaining infection.

Discussion

Reported cases of rabies provide only an index of the magnitude of the disease and do not indicate the actual extent of this virus infection among wildlife or domestic animals of any region. Cases detailed in this report include only those cases of rabies that were laboratory confirmed and reported to the CDC by state and territorial health departments. States have different algorithms for submission of specimens for rabies diagnosis, and levels of surveillance vary. The predominantly passive nature of rabies surveillance and lack of estimates of animal population sizes dictate that prevalence or incidence of rabies cannot be determined for most species. Many rabid animals are never observed and, therefore, go untested and undetected.³⁸

The number of cases of rabies in raccoons in 2004 decreased 2.7% from those reported during 2003; the 2,564 cases reported in 2004 is the lowest annual total of rabid raccoons since the record 5,912 cases reported in 1993. Although raccoons continued to account for the highest percentage (37.5%) of rabies cases reported among animals in the United States in 2004, the magnitude of this ratio and numbers of reported cases of rabies in raccoons continue to decline (Figure 2). However, enzootic transmission of rabies among raccoons, and from those raccoons to other species, was ongoing in 20 states, the District of Columbia, and New York City in 2004. States enzootic for raccoon rabies reported 99.5% (2,551/2,564) of all documented cases of rabies in raccoons and accounted for 65.3% (4,469/6,844) of the national total of rabid animals (72.8% [3,989/5,483] of total cases in terrestrial animals). Periodic increases in numbers of reported cases of rabies in states where the disease is enzootic among raccoons occur when populations of raccoons decimated by a previous epizootic again reach densities sufficient to support transmission of rabies virus.^{9,10}

The first field release of the V-RG vaccine in the United States began during 1990.³⁹ The vaccine was conditionally licensed in April 1995 and was fully licensed in April 1997. Vaccine distribution in each state remains limited to authorized state or federal rabies control programs. Interventions using the V-RG vaccine distributed within baits to vaccinate wild raccoons to prevent or slow the dissemination of rabies continue in a number of states and are being undertaken in additional states. The effectiveness of these programs remains under assessment in multiple states, including Florida (Pinellas County), eastern Massachusetts (Cape Cod),²² southern New Jersey (Cape May),²¹ New York, Vermont, Virginia, West Virginia, and, most recently, in Alabama, Georgia, and Tennessee.

During 2004, multiple state agencies, the CDC, and the USDA continued partnerships and cooperation in a massive undertaking to maintain and expand an "immune barrier" beginning on the shores of Lake Erie in Ohio, Pennsylvania, and New York and intended to eventually reach the Gulf of Mexico in Alabama. In Ohio, almost 800,000 additional doses of ORV baits were distributed over a total of > 4,500 square miles in 15 eastern counties during 2004, extending along the Pennsylvania and West Virginia borders from Lake Erie to the Ohio River.^{40,41,c} Also during 2004, ORV baits were again distributed in Alabama, Georgia, Pennsylvania, Tennessee, Virginia, and West Virginia, thereby expanding and interconnecting existing ORV barriers or initiating new barriers in regions along and ahead of the front of the raccoon rabies enzootic as determined by active and passive rabies surveillance.^{41,42} These ORV programs served to maintain and expand a continuous immune corridor (augmented by geographic barriers such as lakes, rivers, and mountains), extending from the shore of Lake Erie south to extreme northeastern Tennessee. This barrier will be extended further south and eastward over time in an attempt to contain and reduce the area of enzootic rabies in raccoons.^{42,43} Concerns regarding vaccine safety, efficacy, ecologic impact, and physical bait variables, which were raised during earlier trials, continue to be assessed.^{23,24,42-47} Rabid raccoons were reported beyond the ORV barrier zone in Cape Cod, Mass, and rabid raccoons were reported from 2 counties in Ohio that were beyond that state's ORV barrier zone. In addition, infected animals were found from Hamilton County in south central Tennessee, an area new to raccoon rabies. Cases of raccoon rabies in each of these 3 areas represent extensions of the raccoon rabies epizootic: 1) increases in numbers of cases of raccoon rabies that were reported east of the Cape Cod Canal in Massachusetts, 2) west of the Ohio River in the North, and 3) into central Tennessee in the South. Changes in baiting strategies, including additional baiting in and around newly infected areas, were made to sanitize and strengthen areas involved in these recent breaches.

Reports of rabid skunks in 2004 decreased by 12.1% from the number reported in 2003 (Figure 6; Table 1). Fewer states reported decreases in 2004 (22/40 states) than in 2003 (24/35), and more states reported rabies activity involving skunks in 2004 (40) than in 2003 (35). Although Texas again reported the greatest number of rabid skunks during 2004, the 534 cases were 86 fewer than those reported in 2003. Five of the 18 states that reported increases in rabid skunks in 2004 did not report rabid skunks in 2003, and each of these states reported only a single case of rabies in skunks in 2004. In the Southwest, Arizona reported a 200% increase in the number of rabid skunks (n = 24 cases), 5 of which (from Flagstaff) were infected with big brown bat rabies virus variant. This was the site of a previous focal outbreak of rabies in skunks caused by this same variant (19 rabid skunks reported in Coconino County, 2001).⁴⁸ Minnesota (152.2%; 23 cases to 58), Missouri (375%; 4 to 19), and New Hampshire (112.5%; 8 to 17) were the only other states with noteworthy increases in numbers of rabid skunks.

Louisiana reported a rabid skunk in 2003 but did not report a rabid skunk in 2004. Rhode Island reported more rabid skunks (n = 28) than rabid raccoons (9) for the seventh consecutive year in 2004. However, most rabid skunks in states enzootic for raccoon rabies are presumed to be infected with the raccoon rabies virus variant as determined on the basis of those that have been further tested to determine variant type. Studies have been unable to demonstrate evidence of adaptation, circulation, and maintenance of the raccoon rabies virus variant in skunks.⁴⁹ States in which the raccoon-associated variant of the rabies virus is enzootic continue to report > 40% of the cases of rabies in skunks; thus, it may be that < 60% of all reported skunks (those reported rabid in skunk rabies reservoir areas previously defined) are infected with skunk rabies virus variants.

Cases of rabies in foxes in 2004 decreased almost 15% from numbers for 2003. Rabies resulting from the red fox virus variant of the rabies virus in Canada and New England has been controlled, and most cases of rabies in foxes reported by eastern states were probably caused by the rabies virus variant associated with raccoons. This presumption has been supported by those samples further subjected to antigenic and genetic analysis. One of the rabid foxes reported by Arizona in 2004 was from Coconino County and was found to be infected with big brown bat rabies virus variant; however, rabies in gray foxes in Arizona and Texas is usually the result of infection with gray fox variants found in each of those states. Increased success in preventing infections resulting from the Texas gray fox rabies virus variant via the use of an ORV targeted at gray foxes was reported during 2004 (22 cases associated with this variant reported in 2004, compared with 61 cases in 2003). No infections involving the Texas gray fox rabies virus variant occurred outside of the boundaries of the original containment area.^{5,44,d} Twenty-two states reported decreases in numbers of cases of rabies in foxes. Decreases were usually small, with only Maryland (n = 24 cases), South Carolina (21), and Texas (16) reporting decreases of > 10 cases from those reported in 2003. Only 10 states and the District of Columbia reported increases. New York (n = 30 cases) and Virginia (56) reported the greatest increases of 11 and 8 cases, respectively, over 2003. Vermont reported 7 cases of rabies in foxes in 2004 but did not report any cases in 2003. Six states and the District of Columbia reported increases of only a single case; of these, Arkansas, Florida, Iowa, Michigan, Oklahoma, and the District of Columbia did not report any cases in 2003.

The occurrence of rabies in various species of bats fluctuates by geographic region. The continued and increasing association of bat rabies virus variants with human rabies infections in the United States during recent years has brought increased publicity and changes in public health recommendations proposed for rabies exposures potentially involving bats.^{50,51} Rabies among rodents and lagomorphs reflects spillover infection from regional terrestrial reservoir species. Reported cases among rodents occur primarily

in groundhogs (30 cases reported in 2004) in areas of the country affected by the raccoon rabies virus variant.²⁹ Rabies is occasionally reported in other large members of this group, such as beavers and muskrats (1 case of rabies reported in each in 2004).³² Large species of rodents and lagomorphs and those kept in outdoor cages may become infected and survive long enough to pose a risk to other species.⁵³ Rabies is seldom reported in smaller rodents, presumably because of the high degree of mortality and severe trauma that usually result from an attack by a rabid carnivore. There has been no documentation of rabies transmission from a rodent to a human being.

Additional distributions of ORV (1.7 million baits delivered over > 34,000 square miles) were completed during 2004 in Texas to interrupt the transmission of rabies virus in gray foxes and in dogs and coyotes.^{3-5,44,d} Translocations of animals infected with canid rabies virus variants found in Texas have been documented.^{6,7} These events involved infected animals placed in enclosures prior to release at the intended location. Rapid responses to these events may have prevented establishment and spread of the involved variants.

Rabies in domestic animals decreased 11.4% in 2004. Reported cases of rabies in dogs (n = 94) and cats (281) decreased 19.7% and 12.5%, respectively, whereas cases in cattle (115) increased 17.4%. The number of cases of rabies reported in cats was almost 3 times that reported for dogs, more than twice the number reported for cattle, and more than the combined total number of cases reported for dogs and cattle. The number of cases of rabies among sheep and goats (10) decreased 16.7% from 2003. Cases of rabies among horses and mules decreased 31.8% (63 cases in 2003 to 43 cases in 2004). Only Texas (12 cases) and Nebraska (6) reported more than 4 cases of rabies in horses and mules. Continued low numbers of reported cases of rabies in dogs and cattle attest to the effectiveness of a public health strategy aimed at preventing rabies spillover from infected wildlife to domestic animals. Further reduction of the number of cases of rabies in companion species, especially cats, may require stricter observance and enforcement of vaccination and leash laws. Vaccination remains a crucial element in this effort.

In 1999, a study was undertaken to evaluate the epidemiologic features of rabies virus variants responsible for cases of rabies reported in cats and dogs and to assess what contribution, if any, was the result of bat-associated rabies virus variants.⁵⁴ Nearly all animals (229 cats and 78 dogs) were infected via spillover with the predicted terrestrial rabies virus variant. Most cats and dogs were infected with the variant maintained (ie, circulated) in the dominant terrestrial reservoir species in the geographic location where the infection occurred. A single cat from Maryland was found to be infected with a bat-associated rabies virus variant. This important study lends support to earlier hypotheses based mainly on small local samples and presumption.

Vaccination of pet animals and livestock that have regular contact with human beings provides a barrier to protect the human population from infection with rabies. A single incident involving a case of rabies in a companion species can result in large expenditures in

dollars and public health efforts to ensure that human disease does not occur.⁵⁵⁻⁵⁷ Although widespread vaccination of livestock is neither economically feasible nor justifiable on public health grounds, vaccination of valuable livestock or livestock that may have regular contact with human beings in rabies-epizootic areas should be considered.⁵⁰

With the report of 8 human rabies cases in 2004, the total number of cases of rabies diagnosed in human beings in the United States since 1990 increased to 46, and 1 case was reported from Puerto Rico. Ten (21.3%) of these 47 individuals were infected outside the United States. Human rabies cases that are the result of infections occurring abroad are usually in countries where dog rabies is enzootic and involve regional canine rabies virus variants; 6 of 9 such cases and the case from Puerto Rico (7/10) also involved reported history of dog bite. Thirty-seven (78.7%) of the 47 individuals were infected with rabies virus variants indigenous to the United States. Monoclonal antibody analysis and genetic sequencing indicated that 34 (91.9%) of these 37 persons were infected with bat rabies virus variants (14 of 15 [indigenously acquired; 4 received transplants from a rabies-infected donor]) since 2000 (Table 2).^{6,9,10} Although infection of human beings with rabies virus from bats remains a rare occurrence, the prevention of such infection remains an important public health concern.⁴⁶

Rabies in bats is epidemiologically distinct from terrestrial rabies maintained by carnivores. Understanding of the circulation of rabies virus variants in bat species remains less well developed than that in carnivores. Successful control of terrestrial rabies in the United States through the use of oral vaccines, as has been accomplished in Europe^{18,58} and southeastern Canada,⁵⁹ will have no effect on enzootic rabies in bats and the associated risk of human disease.

2005 Rabies Update

During the first 9 months of 2005, 33 reported cases of rabies (30 in raccoons) were attributable to infection with the raccoon rabies virus variant in Ohio.^c The majority of infected animals were detected in counties (Lake and Geauga) that were beyond (west of) those forming the baited zone. Ohio rabies control programs distribute V-RG baits on the basis of data gathered via active surveillance programs implemented in affected areas and via a statewide passive surveillance system. These cases serve as a reminder that immune corridors will not remain effective without continued vigilance as well as cooperation and participation with neighboring states. Bait distribution continues along the front of the raccoon rabies epizootic extending from the shore of Lake Erie in the north, southwest across West Virginia, through westernmost Virginia, and terminating in the northeastern corner of Tennessee. Rabid raccoons continue to be reported in northern Georgia and Tennessee and in several counties in westernmost Virginia, adjacent to Kentucky. The risk for introduction of the raccoon rabies virus variant into Kentucky and other midwestern states remains a major concern.

In March 2004, a rabid raccoon from Bourne, Mass, was reported by Massachusetts health authorities. Barnstable County subsequently reported 123 additional rabid animals (103 rabid raccoons) during 2004. During the first 8 months of 2005, Massachusetts has reported 147 cases (121 raccoons and assorted other species) infected with the raccoon rabies virus variant beyond the 10-year-old Cape Cod ORV barrier.^c Raccoon rabies has now been reported on the previously protected Cape Cod peninsula as far east as the town of Eastham. During 2005, Tennessee has reported 3 raccoons, 1 fox, and 1 skunk that were infected with the raccoon rabies virus variant from 4 counties in eastern and south central locations.^f

Toward the end of August, more than 112 animals (primarily bats and skunks) in the state of Arizona had tested positive for rabies. Thus, the number of rabies cases reported by Arizona in 2005 may surpass the record 143 cases reported in 2002.

In Texas, an additional 2.7 million doses of V-RG vaccine were distributed over > 31,000 square miles during 2005. No animals infected with rabies attributable to the dog/coyote rabies virus variant have been reported by Texas. During this same period, 3 cases of rabies attributable to the Texas gray fox rabies virus variant were reported; however, no cases were reported outside of the original ORV treatment area. Since the programs were initiated in 1995, almost 25.4 million doses of V-RG vaccine have been distributed over > 352,000 square miles in Texas.^d

During 2005, the USDA Animal and Plant Health Inspection Service Wildlife Services and cooperating agencies and partners distributed > 10 million ORV baits over > 200,000 square kilometers in 14 states as part of continuing efforts to control rabies in wildlife reservoir species.⁴²

Rabies has been diagnosed at the CDC from samples from a 10-year-old boy from Mississippi who died of encephalitis on September 27, 2005. This case is currently under investigation.⁶⁰

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