

# Public Veterinary Medicine: Public Health

## Rabies surveillance in the United States during 2003

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**Summary**—During 2003, 49 states and Puerto Rico reported 7,170 cases of rabies in nonhuman animals and 3 cases in human beings to the CDC. This represents a 10% decrease from the 7,967 cases in nonhuman animals and 3 cases in human beings reported in 2002. More than 91% (n = 6,556) were in wild animals, and 8.6% (614) were in domestic species (compared with 92.5% in wild animals and 7.4% in domestic species in 2002). The relative contributions of the major groups of animals were as follows: 2,635 raccoons (36.7%), 2,112 skunks (29.4%), 1,212 bats (16.9%), 456 foxes (6.4%), 321 cats (4.5%), 117 dogs (1.6%), and 98 cattle (1.4%). Compared with cases reported in 2002, the number of cases reported in 2003 decreased among all reporting groups with the exception of cats, dogs, equids, and swine. Ten of the 19 states with enzootic rabies in raccoons, the District of Columbia, and New York City reported decreases in the numbers of rabid raccoons during 2003. Tennessee reported 4 cases of indigenous rabies in raccoons during 2003, becoming the 20th state where rabies in raccoons is known to be enzootic.

On a national level, the number of rabies cases in skunks during 2003 decreased by 13.2% from those reported in 2002. Texas again reported the greatest number (n = 620) of rabid skunks during 2003, as well as the greatest overall state total of rabies cases (909). As in 2002, Texas did not report any cases of rabies associated with the dog/coyote variant of the rabies virus, but did report 61 cases associated with the gray fox variant of the virus (compared with 65 cases in 2002). The 1,212 cases of rabies reported in bats during 2003 represented a decline of nearly 12% from the previous year's record high of 1,373 cases for this group of mammals. Cases of rabies reported in foxes and raccoons declined 10.2% and 8.9%, respectively, during 2003. Rabies among sheep and goats decreased from 15 cases in 2002 to 12 cases in 2003, whereas cases reported in cats, dogs, and equids increased 7.4%, 18.2%, and 8.6%, respectively. In Puerto Rico, reported cases of rabies in mongooses and dogs decreased 26.9% and 35.7%, respectively, from those reported in 2002.

Three cases of rabies in human beings were reported in California, Virginia, and Puerto Rico during 2003. The Virginia case was the first reported occurrence of rabies in a human being infected with the raccoon rabies virus variant; however, the exposure history was unknown. The California and Puerto Rico cases were the result of infections with bat and dog/mongoose rabies virus variants, respectively, and each patient had a history of a bite.

Rabies is primarily a disease that affects and is maintained by wildlife populations in the United States and other developed nations (Figure 1). During 2003, wild animals accounted for more than 91% 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 (Figure 2) because of fluctuations in epizootics of

rabies among animals infected with several distinct variants of the rabies virus.<sup>1</sup>

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 *C familiaris*) by the 1960s. Programs initiated to interrupt transmission of a

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canine variant that reemerged in south Texas during the late 1970s and early 1980s have substantially reduced or eliminated the spread of this variant, which is maintained in coyotes (*C latrans*) and historically transmitted to unvaccinated dogs, as well as a second canine variant found mainly in gray foxes (*Urocyon cinereoargenteus*) in west and central Texas. Regulations now in place in Texas and other states that prohibit translocation of certain wild animal species for hunting and other restocking purposes have substantially reduced the likelihood of accidental introductions of rabies virus variants into unaffected areas.<sup>1-3</sup>

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 of transmission of rabies virus from terrestrial animals to human beings.<sup>4</sup> However, an ever-increasing number of rabies cases in human beings has resulted from infection with variants of the rabies virus that are associated with bats,<sup>5,6</sup> 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 exposure histories involving a bat bite. Since 2000, 8 of 9 cases of indigenously acquired rabies were associated, as determined by genetic analysis, with variants of the rabies virus maintained by bats. Only 2 of these

cases involved a report of a definite history of animal bite.<sup>2,6</sup> The most likely route of infection with rabies virus remains transmission by a bite that either was unnoticed or ignored and subsequently forgotten during 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 even centuries.

Variants of the rabies virus can be identified by reaction with panels of monoclonal antibodies<sup>7</sup> or by patterns of nucleotide substitution determined by genetic analysis.<sup>1,8</sup> The spatial boundaries of enzootic rabies in a reservoir species are temporally dynamic (Figure 3). Affected areas may expand and contract through virus transmission and population interactions.<sup>9,10</sup> 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.<sup>1,3,8-10</sup>

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.<sup>11</sup> Although identifiable as separate foci prior to 1994, the mid-Atlantic and southeastern foci have merged, and raccoon rabies is now enzootic in all of the eastern coastal states, as well as Alabama, Ohio, Pennsylvania, Vermont, and West Virginia.

Three variants of rabies virus are responsible for disease in skunks (primarily *Mephitis mephitis*) in California and the north central and south central states. A long-standing reservoir for rabies virus exists in red and arctic foxes (*Vulpes vulpes* and *Alopex lagopus*, respectively) in Alaska. Rabies spread during the

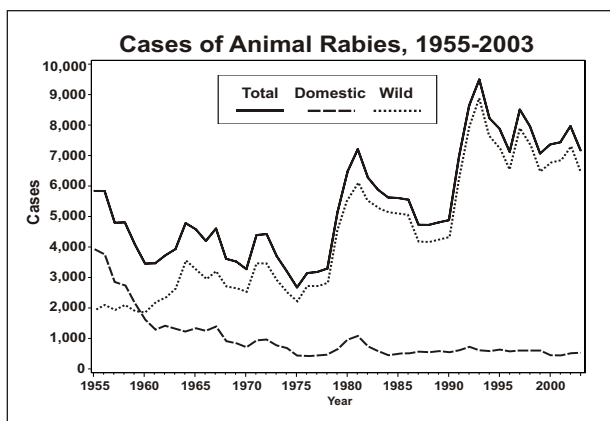


Figure 1—Cases of animal rabies in the United States, by year, 1955 to 2003.

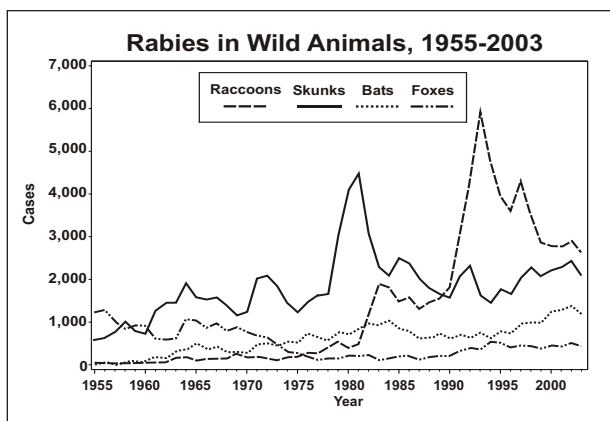


Figure 2—Cases of rabies in wild animals in the United States, by year and species, 1955 to 2003.

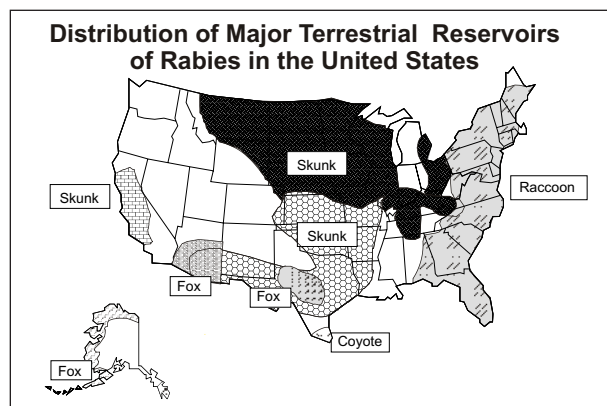


Figure 3—Distribution of major terrestrial reservoirs of rabies in the United States.

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 variants of rabies virus are in geographically limited populations of gray foxes (*U cinereoargenteus*) in Arizona and Texas. Enzootic rabies among canids in south Texas has been the result of longstanding interaction between unvaccinated domestic dogs and coyotes at the Texas-Mexico border<sup>12</sup>; however, no cases associated with the dog/coyote variant of the rabies virus have been reported since February 2001 (as noted in the 2002 report).

The use of population-reduction programs to control rabies among wild terrestrial carnivores is not desirable, and no such undertaking has been successful in North America or elsewhere. Programs in Europe and southeastern Canada have instead used modified-live or recombinant virus vaccines for oral vaccination 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,<sup>13</sup> 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 a similar declaration by France at the end of 2000.<sup>14</sup> Substantial decreases in the number of reported cases of rabies in fox populations in southern Ontario strongly support the observation that variants of the rabies virus associated with red foxes may be eliminated by vaccination. Distribution of an oral **vaccinia-rabies glycoprotein (VRG)** recombinant vaccine targeting raccoons in the eastern United States<sup>15-17</sup> and gray foxes and coyotes in Texas<sup>18</sup> has shown promise as a complement to traditional rabies control methods. However, products used in oral vaccination programs are self-replicating, and the unintentional exposure of nontarget species, including human beings, must be minimized and monitored.<sup>19,20</sup>

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 no 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 sus-

tained 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 2003 with those from 2002 and by examining seasonal patterns for selected species.

Summaries of 2003 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 2004 is also included.

## Collection of Data

Data collection procedures were similar to those described previously.<sup>2</sup> Between January 1 and December 31, 2003, all 50 states, Washington DC, New York City, and Puerto Rico reported the number of cases of rabies in animals to the CDC monthly by county of origin and type of animal. States report cases among most terrestrial mammals by 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 using the Public Health Laboratory Information System or the Laboratory Information Tracking System.<sup>21,22</sup> All year-end totals were confirmed by 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 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 (RT-PCR)** assays were used to confirm some cases.

## Rabies in Wild Animals

Wild animals accounted for 6,556 (91.4%) of the 7,173 reported cases of rabies in 2003 (Figure 1), representing more than an 11.1% decrease from the 7,375 cases reported in 2002 (Table 1). Raccoons continued to be the most frequently reported rabid wildlife species (36.7% of all animal cases during 2003), followed by skunks (29.4%), bats (16.9%), foxes (6.4%), and other wild animals, including rodents and lagomorphs (2.0%). Numbers of reported cases in skunks,

Table 1—Cases of rabies in the United States, by state and category, during 2003.

Rabies in the United States, 2003																			
State (City)	Domestic animals										Wild animals					Human beings	2002	Change\$ %	
	All animals	Domestic	Wild	Dogs	Cats	Cattle	Horses/ mules	Sheep/ goats	Swine	Other domestic*	Skunks	Foxes	Bats	Raccoons	Rodents and lagomorphs†				Other wild‡
AL	68	4	64	—	3	—	1	—	—	—	3	27	33	—	1 <sup>a</sup>	—	78	-12.82	
AK	9	1	8	1	—	—	—	—	—	—	8	—	—	—	—	—	27	-66.67	
AZ	75	0	75	—	—	—	—	—	—	8	18	44	—	—	5 <sup>a</sup>	—	143	-47.55	
AR	69	5	64	2	1	2	—	—	—	56	—	8	—	—	—	—	131	-47.33	
CA	218	3	214	1	2	—	—	—	—	42	10	162	—	—	—	1	253	-13.83	
CO	43	1	42	1	—	—	—	—	—	—	—	42	—	—	—	—	59	-27.12	
CT	188	4	184	—	2	1	—	1	—	57	3	11	112	—	1 <sup>a</sup>	—	331	-43.20	
DC	5	0	5	—	—	—	—	—	—	—	—	1	4	—	—	—	11	-54.55	
DE	65	6	59	—	6	—	—	—	—	9	4	5	39	2 <sup>a</sup>	—	—	55	18.18	
FL	193	17	176	2	15	—	—	—	—	—	28	20	127	—	1 <sup>a</sup>	—	181	6.63	
GA	402	29	373	3	20	1	4	—	1	—	68	43	16	242	—	4 <sup>a</sup>	411	-2.19	
HI	0	0	0	—	—	—	—	—	—	—	—	—	—	—	—	—	0	—	
ID	15	0	15	—	—	—	—	—	—	—	—	15	—	—	—	—	38	-60.53	
IL	24	0	24	—	—	—	—	—	—	—	—	24	—	—	—	—	31	-22.58	
IN	31	0	31	—	—	—	—	—	—	—	—	31	—	—	—	—	32	-3.13	
IA	106	20	86	6	8	3	3	—	—	38	—	47	—	—	1 <sup>a</sup>	—	79	34.18	
KS	166	30	136	3	10	12	4	1	—	124	2	9	1	—	—	—	154	7.79	
KY	39	7	32	5	1	1	—	—	—	20	4	7	1	—	—	—	28	39.29	
LA	4	0	4	—	—	—	—	—	—	1	—	3	—	—	—	—	6	-33.33	
ME	82	2	80	1	—	—	1	—	—	26	5	9	37	2 <sup>a</sup>	1 <sup>a</sup>	—	67	22.39	
MD	371	27	344	2	21	1	1	—	1 <sup>a</sup>	16	37	10	269	11 <sup>d</sup>	1 <sup>a</sup>	—	396	-6.31	
MA	216	8	208	2	6	—	—	—	—	86	13	23	81	3 <sup>a</sup>	2 <sup>a</sup>	—	303	-28.71	
MI	48	1	47	—	1	—	—	—	—	2	—	45	—	—	—	—	46	4.35	
MN	48	13	35	4	4	5	—	—	—	23	—	12	—	—	—	—	47	2.13	
MS	4	0	4	—	—	—	—	—	—	—	—	4	—	—	—	—	4	0.00	
MO	43	2	41	1	1	—	—	—	—	4	—	37	—	—	—	—	46	-6.52	
MT	22	0	22	—	—	—	—	—	—	11	—	11	—	—	—	—	21	4.76	
NE	99	20	79	3	7	6	3	1	—	69	5	5	—	—	—	—	27	266.67	
NV	6	0	6	—	—	—	—	—	—	—	—	6	—	—	—	—	17	-64.71	
NH	29	1	28	—	—	1	—	—	—	8	4	5	11	—	—	—	47	-38.30	
NJ	248	21	227	—	20	—	1	—	—	21	6	62	131	7 <sup>a</sup>	—	—	213	16.43	
NM	7	0	7	—	—	—	—	—	—	2	—	5	—	—	—	—	10	-30.00	
NY	423	34	389	1	27	3	1	2	—	73	19	90	195	5 <sup>a</sup>	7 <sup>a</sup>	—	705	-40.00	
NYC	6	0	6	—	—	—	—	—	—	3	—	—	3	—	—	—	27	-77.78	
NC	769	30	739	6	19	3	2	—	—	111	77	28	518	—	5 <sup>a</sup>	—	706	8.92	
ND	57	17	40	7	5	4	1	—	—	38	—	2	—	—	—	—	59	-3.39	
OH	53	1	52	—	1	—	—	—	—	—	2	48	2	—	—	—	39	35.90	
OK	204	49	155	16	9	16	8	—	—	147	—	7	—	—	1 <sup>a</sup>	—	126	61.90	
OR	7	0	7	—	—	—	—	—	—	—	1	6	—	—	—	—	14	-50.00	
PA	429	49	380	—	43	3	3	—	—	80	28	35	234	1 <sup>b</sup>	2 <sup>aa</sup>	—	496	-13.51	
PR	71	21	49	9	2	—	10	—	—	—	—	—	—	—	49 <sup>bb</sup>	1	87	-18.39	
RI	71	2	69	—	2	—	—	—	—	34	5	4	23	3 <sup>c</sup>	—	—	83	-14.46	
SC	276	21	255	2	17	2	—	—	—	37	46	4	165	—	3 <sup>cc</sup>	—	162	70.37	
SD	132	36	96	11	6	14	5	—	—	86	1	8	1	—	—	—	96	37.50	
TN	103	8	95	3	1	—	4	—	—	74	2	15	4	—	—	—	111	-7.21	
TX	909	69	840	19	25	10	8	7	—	620	28	169	11	—	12 <sup>dd</sup>	—	1,049	-13.35	
UT	14	0	14	—	—	—	—	—	—	—	—	14	—	—	—	—	13	7.69	
VT	38	0	38	—	—	—	—	—	—	14	—	4	19	1 <sup>i</sup>	—	—	91	-58.24	
VA	543	53	489	6	34	10	3	—	—	92	48	19	321	2 <sup>a</sup>	7 <sup>ee</sup>	1	592	-8.28	
WA	23	0	23	—	—	—	—	—	—	—	—	23	—	—	—	—	13	76.92	
WV	83	1	82	—	1	—	—	—	—	11	6	13	51	1 <sup>aa</sup>	—	—	175	-52.57	
WI	14	1	13	—	1	—	—	—	—	—	—	13	—	—	—	—	16	-12.50	
WY	5	0	5	—	—	—	—	—	—	1	—	4	—	—	—	—	18	-72.22	
<b>Total</b>	<b>7,173</b>	<b>614</b>	<b>6,556</b>	<b>117</b>	<b>321</b>	<b>98</b>	<b>63</b>	<b>12</b>	<b>2</b>	<b>1</b>	<b>2,112</b>	<b>456</b>	<b>1,212</b>	<b>2,635</b>	<b>38</b>	<b>103</b>	<b>3</b>	<b>7,970</b>	<b>-10.00</b>
% 2003§	100.00	8.56	91.40	1.63	4.48	1.37	0.88	0.17	0.03	0.01	29.44	6.36	16.90	36.73	0.53	1.44	0.04		
Total 2002	7,970	592	7,375	99	299	116	58	15	1	4	2,433	508	1,373	2,891	52	118	3		
% Change¶	-10.00	3.72	-11.11	18.18	7.36	-15.52	8.62	-20.00	100.00	-75.00	-13.20	-10.24	-11.73	-8.86	-26.92	-12.71	0.00		

\*Other domestic includes: <sup>1</sup> ferret. †Rodents and lagomorphs include: <sup>2</sup> groundhogs; <sup>2</sup> groundhogs; <sup>11</sup> groundhogs; <sup>2</sup> groundhogs, 1 squirrel; <sup>6</sup> groundhogs, 1 rabbit; <sup>4</sup> groundhogs, 1 guinea pig; <sup>1</sup> groundhog; <sup>2</sup> groundhogs, 1 rabbit; <sup>1</sup> groundhog; <sup>1</sup> beaver, 1 rat; <sup>1</sup> beaver. ‡Other wild includes: <sup>1</sup> opossum; <sup>1</sup> coyote, 4 bobcats; <sup>1</sup> bobcat; <sup>1</sup> otter; <sup>1</sup> coyote, 3 bobcats; <sup>1</sup> badger; <sup>1</sup> bobcat; <sup>1</sup> opossum; <sup>2</sup> bobcats; <sup>1</sup> bear, 2 bobcats, 1 coyote, 2 deer, 1 otter; <sup>4</sup> bobcats, 1 deer; <sup>1</sup> bobcat; <sup>1</sup> bobcat, 1 deer; <sup>49</sup> mongooses; <sup>3</sup> bobcats; <sup>8</sup> bobcats, 3 coyotes, 1 ringtail; <sup>4</sup> bobcats, 1 coyote, 1 opossum, 1 otter. §Percentage of all rabid animals in 2003. ||2002 Total by species. ¶Percent change from 2002.

bats, foxes, and raccoons decreased 13.2%, 11.7%, 10.2%, and 8.9%, from 2002 totals, respectively.

**Raccoons**—The 2,635 cases of rabies in raccoons (*P. lotor*) reported in 2003 represented a 5-year low for this species (Figures 2 and 4). Decreases in numbers of

rabid raccoons during 2003 were reported by 10 of the 20 eastern states in which raccoon rabies has been enzootic, including Connecticut (38.8% decrease; 183 cases in 2002 to 112 in 2003), Georgia (2.0%; 247 to 242), Maryland (1.1%; 272 to 269), Massachusetts (4.7%; 85 to 81), New Hampshire (57.7%; 26 to 11),

New York (42.5%; 339 to 195), Pennsylvania (19.0%; 289 to 234), Rhode Island (25.8%; 31 to 23), Vermont (71.6%; 67 to 19), and West Virginia (59.5%; 126 to 51). Decreases were also reported by the District of Columbia (50%; 8 to 4) and New York City (81.3%; 16 to 3) (Figures 4 and 5; Table 1).<sup>2,8-11,15,23</sup> Seven states with well-documented enzootic raccoon rabies reported increases in numbers of rabid raccoons, including Alabama (57.1% increase), Delaware (21.9%), Florida (10.4%), New Jersey (11.0%), North Carolina (13.8%), South Carolina (83.3%), and Virginia (0.9%). Maine (n = 37) reported no change in number of rabid raccoons for 2003.

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 58.1% (n = 1,532) of the total rabies cases in raccoons in 2003. The southeastern states of Alabama, Florida, Georgia, North Carolina, South Carolina, and Tennessee reported 41.3% (n = 1,089) of the total cases in raccoons.

Ohio reported 2 cases of rabies in raccoons infected with the raccoon variant of the rabies virus, an indi-

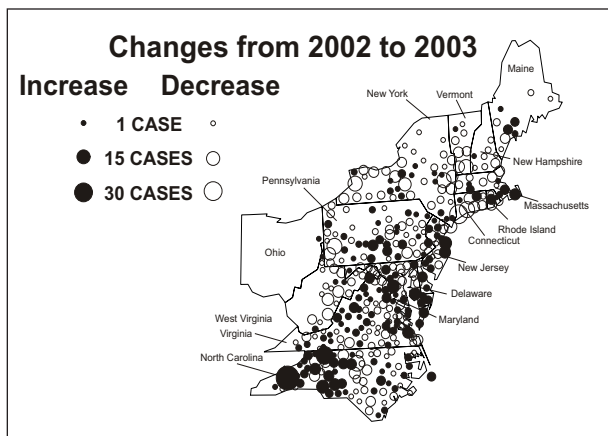


Figure 4—Changes in cases of rabies in raccoons in the mid-Atlantic and northeastern states, 2002 to 2003. Dot size is proportional to the number of cases in the county.

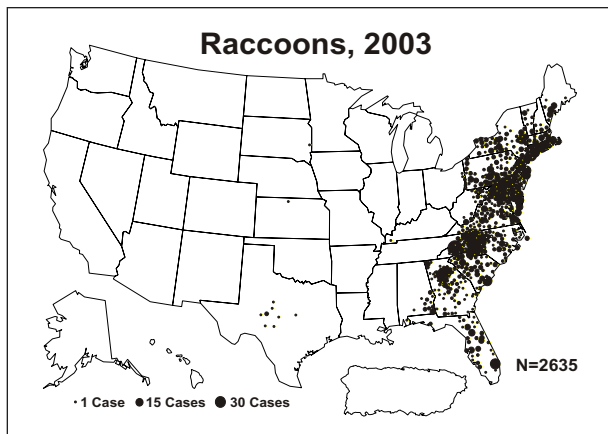


Figure 5—Reported cases of rabies in raccoons, by county, 2003.

cation that enzootic transmission may be occurring despite the distribution of oral rabies vaccine (ORV). Tennessee reported 4 cases of raccoon rabies in raccoons that had been indigenously infected and, thereby, became the 20th state with enzootic raccoon rabies. Thus, more individual cases of rabies associated with the epizootic of rabies in raccoons were reported west of the Ohio River in the North and west of the Appalachian Ridge in the South during 2003. Kansas, Kentucky, and South Dakota each reported single cases of rabies in raccoons infected with regional skunk variants of the rabies virus. Rabid raccoons reported by Texas (n = 11) were the result of spillover infection with variants of the rabies virus other than that associated with raccoons (usually the gray fox variant or the south central skunk variant).

**Skunks**—The 2,112 reported cases of rabies in skunks (mainly *M. mephitis*) in 2003 represented a 13.2% decrease from the number reported in 2002 (Figure 6; Table 1). Twenty-four of 38 states and New York City reported decreased numbers, and decreases of  $\geq 50\%$  from 2002 were reported by Alabama (200%; 2 cases in 2002 to 0 cases in 2003), Arizona (81.8%; 44 to 8), Indiana (100%; 1 to 0), Louisiana (50%; 2 to 1), Maryland (52.9%; 34 to 16), Missouri (71.4%; 14 to 4), West Virginia (54.2%; 24 to 11), Wisconsin (400%; 4 to 0), and Wyoming (88.9%; 9 to 1). On the other hand, 13 states reported increases in numbers of rabid skunks in 2003. Texas reported the greatest number (n = 620) and the greatest overall state total of rabies cases (909) during 2003, and Nebraska reported the greatest increase (2,200%; from 3 cases in 2002 to 69 cases in 2003). The only other states that reported increases of  $> 50\%$ , compared with cases reported in 2002, were Delaware (125%; from 4 cases to 9), Minnesota (64.3%; 14 to 23), Oklahoma (59.8%; 92 to 147), and South Carolina (117.6%; 17 to 37). Alabama, Indiana, and Wisconsin reported 2, 1, and 4 cases, respectively, in 2002, but did not report rabies in skunks during 2003. States in which the raccoon-associated variant of the rabies virus is enzootic reported 38.7% (817/2,112) of the cases of rabies in skunks, the majority of which were presumably the result of spillover transmission of virus from raccoons (35.2% [743/2,112], excluding rabid skunks from only recently enzootic Tennessee).

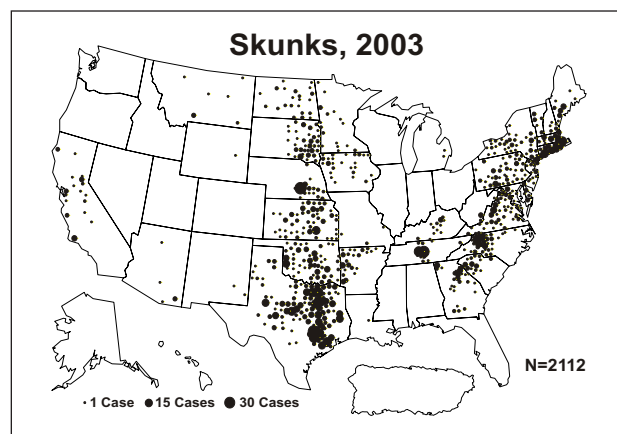


Figure 6—Reported cases of rabies in skunks, by county, 2003.

Massachusetts (n = 86) and Rhode Island (34) each reported more rabid skunks than rabid raccoons for a seventh consecutive year. Michigan (n = 2) did not report any change in the number of rabid skunks.

**Bats**—Rabies in bats accounted for 16.9% of all cases of rabies in animals reported in 2003 (Table 1). The 1,212 cases in 2003 represented a decrease of 11.7% from those reported in 2002 and the first decrease in reported rabid bats since the year 2000. Rabies in bats is widely distributed throughout the United States, with cases reported from all 48 contiguous states (Figure 7). During 2003, Texas reported the largest number of cases (169), followed by California (162) and New York (90). Seven states (Idaho, Illinois, Indiana, Mississippi, Nevada, Utah, and Washington) reported rabies in bats but not in terrestrial mammals. Alaska, Hawaii, and Puerto Rico did not report any cases of rabies in bats.

Of the bats infected with the rabies virus, 55.1% (668/1,212) were identified beyond the taxonomic level of order (8 to genus and 660 to species). Among bats identified to species level, 46.5% (307/660) were *Eptesicus fuscus*, the big brown bat; 27.4% (181/660) were *Tadarida brasiliensis*, the Brazilian (Mexican) free-tailed bat; 5.9% (39/660) were *Lasiurus borealis*, the red bat; 5.8% (38/660) were *L. cinereus*, the hoary bat; 3.0% (20/660) were *Myotis lucifugus*, the little brown bat; 2.0% (13/660) were *L. seminolus*, the Seminole bat; 1.7% (11/660) were *Lasionycteris noctivagans*, the silver-haired bat; 1.2% (8/660) were *Pipistrellus hesperus*, the western pipistrelle; 1.1% (7/660) were *Nycticeius humeralis*, the evening bat; 0.9% (6/660) were *M. yumanensis*, the Yuma bat; and 0.8% (5/660) each were *M. californicus*, the California bat; *M. evotis*, the long-eared Myotis; and *P. subflavus*, the eastern pipistrelle. Unspecified bats of the genus *Myotis* (1.2% [8/668 cases]) and 7 other species (contributing < 2.3% [15/668] to the total, with no individual species in this latter group contributing > 0.6%) accounted for the remaining rabid bats. Not all states were able to speciate bats, nor did all states report total numbers of bats tested for rabies.

**Foxes**—Foxes (mainly *Vulpes*) accounted for 6.4% of all cases of rabies in animals reported in 2003 (Table 1). The 456 cases of rabies in foxes represented

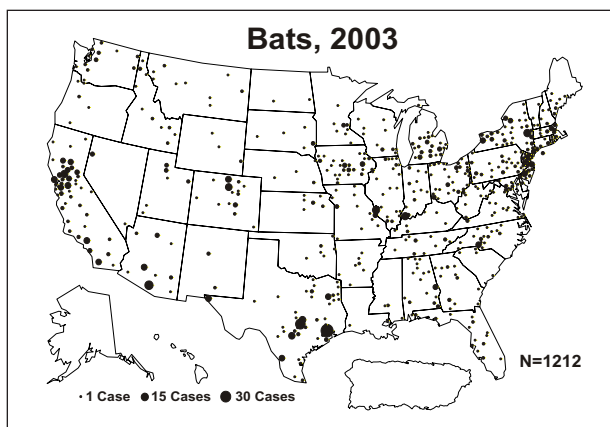


Figure 7—Reported cases of rabies in bats, by county, 2003.

a 10.2% decrease from 2002, and most (n = 377) were reported by states affected by the raccoon-associated variant of the rabies virus (Figure 8). Alaska (n = 8), Arizona (18), Georgia (43), New York (19), and Texas (28) reported decreases of 18, 15, 16, 19, and 20 cases, respectively, from 2002. North Carolina (n = 77) and South Carolina (46) reported increases of 29 and 17 cases, respectively, over 2002. Most cases of rabies in foxes reported by eastern states were probably caused by the rabies virus variant associated with raccoons, with the possible exceptions of Maine, New York, and Vermont. 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. Arkansas, Nevada, Oklahoma, and Vermont reported rabid foxes in 2002, but did not report any in 2003. Kentucky (n = 4), Ohio (2), and South Dakota (1) reported rabid foxes in 2003, but not in 2002.

**Other wild animals**—Puerto Rico reported 49 rabid mongooses (*Herpestes javanicus*) during 2003, a 26.9% decrease from the 67 cases reported in 2002 (Figure 9). Other wildlife in which rabies was reported included 34 bobcats (*Lynx rufus*), 31 groundhogs (*Marmota monax*), 7 coyotes (*C. latrans*), 4 white-tailed deer (*Odocoileus virginianus*), 3 river otters (*Lontra canadensis*), 3 opossums (*Didelphis virginiana*), 2

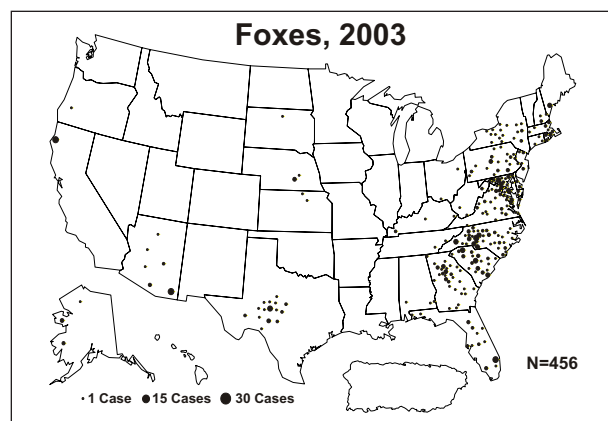


Figure 8—Reported cases of rabies in foxes, by county, 2003.

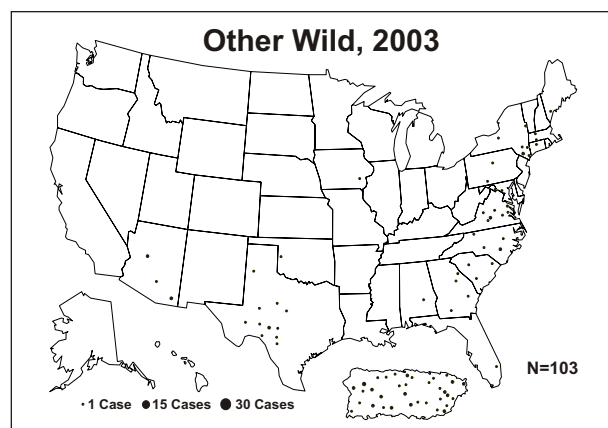


Figure 9—Reported cases of rabies in "Other wild" category of Table 1, by county and municipio (Puerto Rico), 2003.

beavers (*Castor canadensis*), 2 rabbits (*Oryctolagus cuniculus*), 1 badger (*Taxidea taxus*), 1 black bear (*Ursus americanus*), 1 guinea pig (*Cavea porcellus*), 1 rat (*Rattus* sp), 1 ringtail (*Bassariscus astutus*), and 1 gray squirrel (*Sciurus carolinensis*).<sup>24,25</sup> All cases of rabies in rodents and lagomorphs (primarily groundhogs, 31/38 cases) were reported by states in which rabies is epizootic in raccoons.<sup>25</sup> No cases of rabies in coyotes were associated with enzootic transmission of the dog/coyote variant of the rabies virus in regions of south Texas (Figure 9; Table 1).

### Rabies in Domestic Animals

Domestic species accounted for 8.6% of all rabid animals reported in the United States in 2003 (Table 1). The number of domestic animals reported rabid in 2003 (n = 614) represented a 3.7% increase over the total reported in 2002 (Figure 10). Cases of rabies reported in cats and dogs increased 7.4% and 18.2%, respectively, compared with totals reported in 2002. Texas reported the largest number of rabid domestic animals (n = 69), followed by Virginia (53), Oklahoma (49), Pennsylvania (49), South Dakota (36), and New York (34).

**Cats**—Most (n = 238) of the 321 cases of rabies in cats were reported from states in which the raccoon-associated variant of the rabies virus is present (Figure 11).

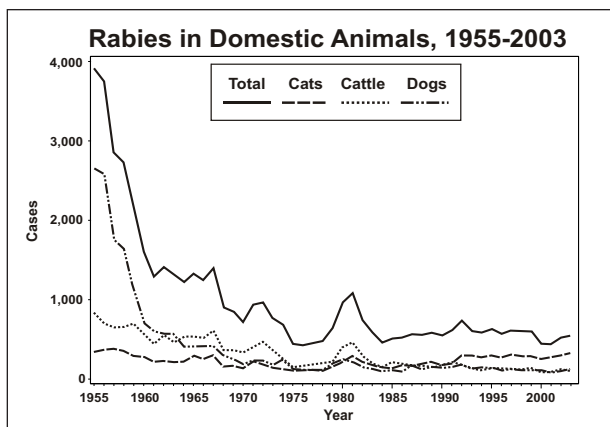


Figure 10—Cases of rabies in domestic animals in the United States, by year, 1955 to 2003.

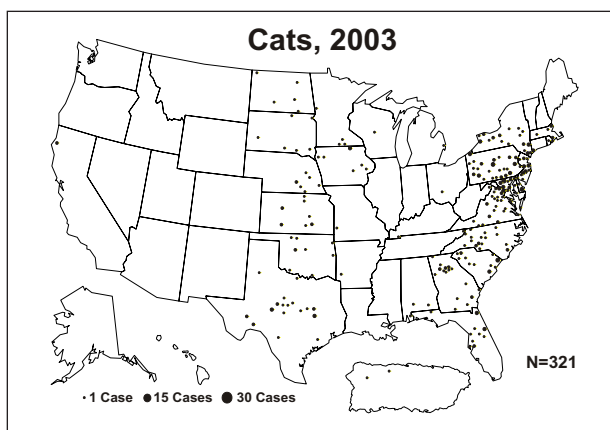


Figure 11—Reported cases of rabies in cats, by county and municipio (Puerto Rico), 2003.

Remaining cases were reported principally by Central Plains states, where most cases were presumably the result of spillover from rabid skunks or rabid foxes in Texas. Ten states reported  $\geq 15$  cases of rabies in cats (Pennsylvania, n = 43; Virginia, 34; New York, 27; Texas, 25; Maryland, 21; Georgia, 20; New Jersey, 20; North Carolina, 19; South Carolina, 17; and Florida, 15). Nineteen states and the District of Columbia did not report any rabid cats.

**Dogs**—Texas (n = 19), Oklahoma (16), South Dakota (11), Puerto Rico (9), and North Dakota (7) reported the largest numbers of cases of rabies in dogs by individual states or territories in 2003. None of the cases in dogs reported by Texas were associated with enzootic transmission of the dog/coyote variant of the rabies virus previously evident in south Texas (Figure 12; Table 1). Other than Iowa (n = 6), North Carolina (6), Virginia (6), and Kentucky (5), no additional states reported  $> 4$  cases of rabies in dogs in 2003. Twenty-six 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 decreased from 116 in 2002 to 98 in 2003 (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).

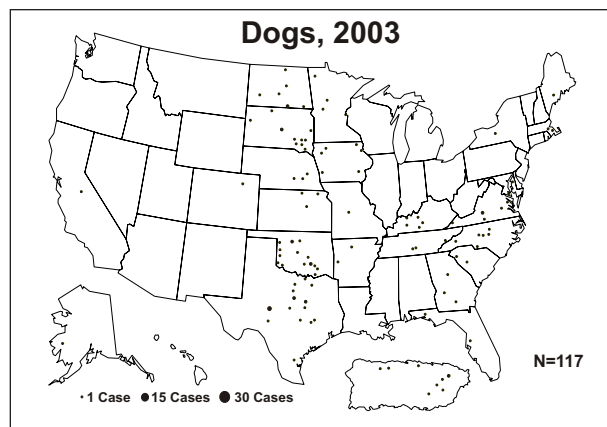


Figure 12—Reported cases of rabies in dogs, by county and municipio (Puerto Rico), 2003.

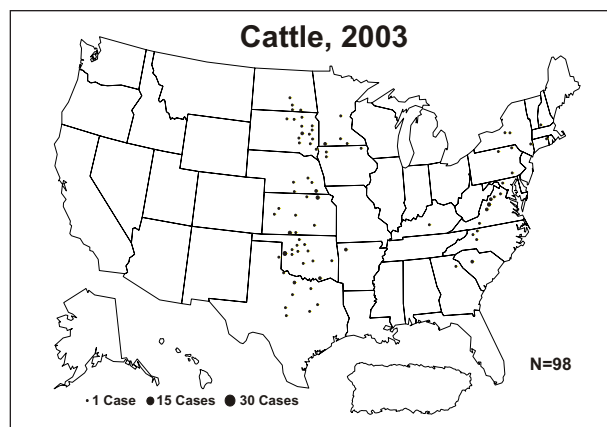


Figure 13—Reported cases of rabies in cattle, by county, 2003.

Oklahoma (n = 16), South Dakota (14), Kansas (12), Texas (10), and Virginia (10) reported the largest numbers of rabid cattle. No other states reported > 6 cases of rabies in cattle. The 63 cases of rabies reported in horses and mules (including donkeys) in 2003 represented an 8.6% increase over the 58 cases reported during 2002. Other reported cases of rabies in domestic animals included 1 ferret, 11 goats, 1 sheep, and 2 swine.

### Seasonal Trends

The frequency of reported cases of rabies in skunks was highest in March, with only slight decline to June. This was followed by a slight increase in September and October and a rapid decline to a December low (Figure 14). The frequency of reporting for rabid raccoons showed a peak in March and April, followed by a decline into the summer months, a small increase in September and October, and a gradual decline into December. Reports of rabid bats increased through the spring and early summer months to a sharp peak in August followed by a steep decline. Reports of rabid foxes increased gradually from March to a broad summer high (May through August), followed by a drop in September and gradual further decline to a low in November.

Following a January through March winter lull, reports of rabid cats rose steeply to a peak in July and then dropped precipitously in August and September (Figure 15). This decline was followed by an increase

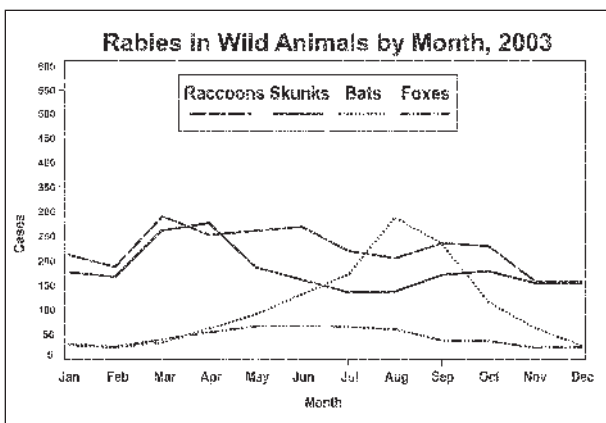


Figure 14—Cases of rabies in wild animals in the United States, by month, 2003.

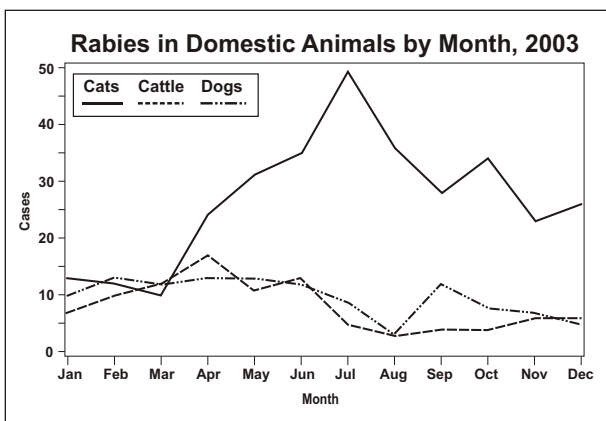


Figure 15—Cases of rabies in domestic animals in the United States, by month, 2003.

to a lower October reporting peak and then a second sharp decline to a November low. Reports of rabies cases in dogs plateaued broadly from January to June before declining to an August low. Reports then increased sharply in September before a gradual decline to a December low. Reported cases in cattle increased to an April peak prior to an undulating decline to an August low, before rising again slightly during the remainder of the year (Figure 15).

### Rabies in Human Beings

Two cases of rabies in human beings were reported in the United States, and 1 case was reported in Puerto Rico during 2003 (Table 2).<sup>2,26,27</sup>

On March 10, 2003, a 25-year-old man residing in Fairfax County, Virginia, died of rabies encephalitis. The variant of the rabies virus that caused this infection

Table 2—Cases of rabies in human beings in the United States and Puerto Rico, 2000 through September 2004,\* 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
N/A	WI	Bite	Bat, pending

\*All laboratory-confirmed cases of rabies in human beings who developed the disease in the United States and Puerto Rico, 2000 to 2004. †Data for exposure history are reported only when the biting animal was available and tested positive for rabies, 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.

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



was that associated with rabies in raccoons (*P. lotor*) in the eastern United States; this was the first infection of a human being by the raccoon rabies variant that has ever been documented. The case was diagnosed retrospectively, and the man's friends and relatives could not recall a history of animal bite or exposure.<sup>26</sup>

On June 5, 2003, a 64-year-old man residing in Canovanas Municipio, Puerto Rico, died of rabies. The variant of the rabies virus that caused this infection was identified as that maintained by mongooses (*H. javanicus*) and unvaccinated dogs (*C. lupus [familiaris]*) in Puerto Rico. The man had a history of dog bite, but did not receive rabies postexposure prophylaxis until after onset of symptoms. This was the first case of human rabies reported by Puerto Rico since a case confirmed retrospectively in 1975.<sup>3</sup>

On September 14, 2003, a 66-year-old man residing in Trinity County, Calif, died of rabies. The variant of the rabies virus that caused this infection was identified as that associated with silver-haired and eastern pipistrelle (*L. noctivagans* and *P. subflavus*) bats. The man had been bitten by a bat about 6 weeks earlier but did not seek public health advice or rabies postexposure treatment as a result of the incident.<sup>27</sup>

### Rabies in Canada and Mexico

Canada reported 264 laboratory-confirmed and 1 clinically diagnosed cases of rabies in domestic and wild animals in 2003. This number represented a 24.4% decrease from the 349 rabies cases reported in 2002. The decrease was attributable to fewer reported cases of rabies in foxes (*V. vulpes* and *A. lagopus*), raccoons, and skunks (*M. mephitis*). Reported cases in foxes decreased 56.9% (28 cases in 2003, compared with 65 in 2002); cases of rabies in raccoons decreased 38.5% (16 in 2003, compared with 26 in 2002); and cases of rabies in skunks in Canada decreased 24.8% (76 in 2003, compared with 101 in 2002). Foxes, raccoons, and skunks accounted for 10.6%, 6.0%, and 28.7%, respectively, of all rabid animals reported in 2003. Other notable contributions to the 2003 Canadian total included bats (43.4%), cattle (4.2%), cats (1.9%), dogs (1.5%), sheep (1.5%), and equids (0.8%). On January 30, 2003, a 52-year-old man from British Columbia, Canada, died of rabies encephalitis caused by a bat-associated rabies virus (variant, *Myotis* bat, *Myotis* sp). The patient had no history of animal bite, and the diagnosis was made > 1 month after his death. More than 450 persons were given rabies postexposure prophylaxis because of known or possible exposure to this patient.<sup>28</sup>

Mexico reported 330 laboratory-confirmed cases of rabies in domestic and wild animals during 2003. This was a decrease of 1 case from the 331 cases reported in 2002. Dogs accounted for 22.7% (75/330) of reported cases of rabies, a decrease of 28.6% from 2002 (n = 105). The other reported rabid animals included 201 cattle, 13 bats, 7 cats, 11 equids, 9 skunks (several species), 7 sheep, 3 goats, 2 foxes (species unknown), 1 badger (*T. taxus*), and 1 wild cat (presumably a bobcat [*L. rufus*]). One case of rabies was reported in a human being in 2003, compared with 2 cases in 2002. The source animal implicated in the exposure of the human being was a dog.

### Discussion

States have different algorithms for submission of specimens for rabies testing 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.<sup>29</sup>

Reported cases of rabies provide only an index of the magnitude of the disease and do not indicate the extent of viral 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.

The number of cases of rabies in raccoons in 2003 decreased 8.9% from those reported during 2002; the number reported in 2002 showed only a relatively minor (4.5%) increase after 5 previous consecutive years of declines. In 2003, raccoons continued to account for the highest percentage (36.7%) of rabies cases reported among animals in the United States; however, the magnitude of this ratio and numbers of reported cases of rabies in raccoons continue to decline (Figure 2). Enzootic transmission of rabies among raccoons was apparent in 20 states and the District of Columbia in 2003. The reported cases of raccoon rabies from Carter County in extreme eastern Tennessee indicate that the raccoon variant of the rabies virus is now enzootic in this state. In 2003, states in the affected area reported 99.5% (2,621/2,635) of all documented cases of rabies in raccoons and accounted for 65.0% (4,661/7,173) of the total cases of rabies (71.8% [4,280/5,961] of total cases in terrestrial animals). Periodic increases in numbers of reported cases of rabies in states where the disease is enzootic among raccoons can and do occur when populations of raccoons decimated by a previous epizootic again reach densities sufficient to support transmission of rabies virus.<sup>9,10</sup>

The first field release of the V-RG vaccine in the United States began during 1990.<sup>30</sup> 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 efficacy of these programs remains under assessment in Florida (Pinellas County), eastern Massachusetts (Cape Cod),<sup>17</sup> southern New Jersey (Cape May),<sup>16</sup> New York, Vermont, Virginia, West Virginia, and, most recently, Alabama, Georgia, and Tennessee.

During 2003, 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. Oral rabies vaccine baits are being used to accomplish this,

and > 638,000 additional doses of ORV baits were distributed during the late summer through fall of 2003 over a total of > 3,100 square miles in 9 eastern Ohio counties extending along the Pennsylvania and West Virginia borders from Lake Erie to the Ohio River.<sup>31,32,b</sup> Also during the fall of 2003, ORV baits were 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.<sup>31</sup> These ORV programs during 2003 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 “cordone sanitaire” will be extended further south and moved eastward over time in an attempt to contain and reduce the area of enzootic rabies in raccoons.<sup>33</sup> Concerns regarding vaccine safety, efficacy, ecologic impact, and physical bait variables, which were raised during earlier trials, continue to be assessed.<sup>19,20,34-36</sup>

Reports of rabid skunks in 2003 decreased by 13.2% from those reported in 2002, and in a reversal of increases in reporting observed in 2002, 24 of 35 states that reported rabid skunks in 2002 or 2003 reported decreases in numbers of rabid skunks in 2003. However, sheer numbers of rabid skunks reported by Kansas (n = 124), Nebraska (69), Oklahoma (147), South Dakota (86), and Texas (620) in 2003 stand out, especially those in Nebraska, a state that reported only 3 rabid skunks during the previous year. Although surveillance changes have taken place in Nebraska, historically a reporter of relatively few rabid skunks and other rabid species, ongoing surveillance clearly demonstrates enzootic transmission of skunk rabies variants in all of these Central Plains states. In Arizona, 1 rabid skunk infected with Arizona gray fox variant of the rabies virus was reported from the Flagstaff area, previously the site of a focal outbreak of rabies in skunks (Coconino County, 2001) resulting from apparent enzootic transmission of a bat rabies variant of the rabies virus. Texas again reported the greatest number of rabid skunks during 2003; however, the 620 cases reported were 120 fewer than those reported in 2002. Although 13 states reported increases in numbers of rabid skunks in 2003, with the exception of those states already addressed, other increases were unremarkable. Only 2 states (Alabama and Wisconsin) that reported rabid skunks in 2002 did not report rabid skunks in 2003. Massachusetts (n = 86) and Rhode Island (34) each reported more rabid skunks than rabid raccoons for the seventh consecutive year. However, most rabid skunks in these and other states enzootic for raccoon rabies are presumed to be infected with the raccoon variant of the rabies virus 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 variant of the rabies virus in skunks.<sup>37</sup> States in which the raccoon-associated variant of the rabies virus is enzootic reported > 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 variants of the rabies virus.

Cases of rabies in foxes in 2003 decreased 10.2% from numbers for 2002. Rabies resulting from the red fox variant of the rabies virus in Canada and New England has been controlled; 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 rabies virus variant analysis. Rabies in gray foxes in Arizona and Texas is usually the result of infection with gray fox variants found in each of those states. Reduced success in preventing infections resulting from the Texas gray fox variant of the rabies virus via the use of an ORV in baits targeted at gray foxes observed during 2002 continued in 2003; however, no infections occurred outside the boundaries of the original containment area.<sup>c</sup> Eighteen states reported decreases in numbers of cases of rabies in foxes. Although decreases were usually small, Alaska (n = 8), Arizona (18), Georgia (43), New York (19), and Texas (28) reported decreases of  $\geq 15$  cases. In contrast, 12 states reported increases in numbers of rabid foxes; however, these increases were also usually small. Maryland, New Jersey, Nebraska, New Hampshire, and Ohio reported increases of 7, 3, 2, 2, and 2 cases, respectively; only North Carolina and South Carolina, with 29 and 17 more cases than in 2002, respectively, reported increases of > 7 cases.

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.<sup>38,39</sup> Rabies among rodents and lagomorphs reflects spillover infection, predominantly from regional terrestrial reservoir species. Reported cases among rodents occur primarily in groundhogs in areas of the country affected by the raccoon-associated variant of the rabies virus.<sup>25</sup> Rabies is occasionally reported in other large members of this group, such as beavers (2 cases in 2003).<sup>40</sup> 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 (eg, 2 cases in rabbits during 2003). Rabies is seldom reported in smaller rodents (1 case each in a guinea pig, rat, and squirrel during 2003), 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 (2.5 million baits delivered over > 31,000 square miles) were completed during 2003 in Texas to interrupt the transmission of rabies virus in gray foxes and in dogs and coyotes.<sup>18,41,42,c</sup> Translocations of animals infected with canid variants of the rabies virus found in Texas have been documented.<sup>2,3</sup> 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 increased 3.7% in 2003. Reported cases of rabies in dogs (n = 117) and cats (321) increased 18.2% and 7.4%, respectively, whereas cases in cattle (98) decreased 15.5%. The number of cases of rabies reported in cats was more than 3 times that reported for cattle, more than twice (2.7) the number reported for dogs, and more than the combined total number of cases reported for dogs and cattle. The number of cases of rabies among sheep and goats decreased from 15 in 2002 to 12 in 2003. Cases of rabies among horses and mules increased 8.6% (58 cases in 2002 to 63 in 2003). Only Oklahoma (n = 8), Puerto Rico (10), and Texas (8) reported more than 5 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<sup>43</sup> was undertaken to evaluate the epidemiologic features of variants of the rabies virus responsible for cases of rabies reported in cats and dogs and to assess what contribution, if any, was the result of bat-associated variants of the rabies virus. Nearly all animals (229 cats and 78 dogs) were infected via spillover with the predicted terrestrial variant of the rabies virus. The variant was 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 variant of the rabies virus. 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. This fact cannot be overemphasized. 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.<sup>44-46</sup> 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.<sup>38</sup>

With the report of 3 human rabies cases in 2003, the total number of cases of rabies diagnosed in human beings in the United States since 1990 increased to 38, and 1 case was reported from Puerto Rico. Eight (20.5%) of these 39 individuals were infected outside the United States. Human rabies cases that are the result of infections that occur abroad usually are documented in countries where dog rabies is enzootic and involve regional canine variants of the rabies virus. Five of 7 such cases and the case from Puerto Rico (6/8) involved reported history of dog bite. Thirty-one (79.5%) of the

39 individuals were infected with variants of the rabies virus indigenous to the United States. Monoclonal antibody analysis and genetic sequencing indicated that 28 (90.3%) of these 31 persons were infected with variants of the rabies virus associated with bats (8 of 9 since 2000; Table 2).<sup>2,5,6</sup> 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.<sup>35</sup>

Rabies in bats is epidemiologically distinct from terrestrial rabies maintained by carnivores. Understanding of the circulation of variants of the rabies virus 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<sup>13,47</sup> and southeastern Canada,<sup>48</sup> will have no effect on enzootic rabies in bats and the associated risk of human disease.

## 2004 Rabies Update

During the first 9 months of 2004, 37 cases (in raccoons) of rabies were reported that were attributable to infection with the raccoon variant of the rabies virus in Ohio.<sup>49</sup> The infected animals were detected in counties that were beyond (west of) those forming the baited "corridor sanitaire." 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 so 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 currently terminating in the eastern corner of Tennessee.<sup>50</sup> Additional baits also have been distributed in an area that includes northeastern Alabama, northern Georgia, and southern Tennessee. Rabid raccoons continue to be reported in northern Georgia and Tennessee and in several counties in westernmost Virginia, adjacent to Kentucky. Thus, raccoon rabies may soon be detected in Kentucky. The risk of introduction of the raccoon-associated variant of the rabies virus 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. Since March, Massachusetts has reported 45 cases of rabies in raccoons beyond the 10-year-old Cape Cod ORV barrier.<sup>d</sup> Raccoon rabies now threatens the metropolitan Boston area. During 2004, Tennessee has reported 6 cases of rabies in raccoons, and the state has also reported 1 fox and 1 skunk (of 17) that were infected with the raccoon variant of the rabies virus.<sup>e</sup>

In Texas, an additional 2.7 million doses of V-RG vaccine were distributed over > 34,700 square miles during 2004. A single case of rabies attributable to the dog/coyote variant of the rabies virus was reported in Texas. During this same period, 21 cases of rabies attributable to the variant of the rabies virus associated with gray foxes were reported in foxes and other species; however, no cases were reported outside of the original ORV treatment area. Since the programs were

initiated in 1995, almost 22.7 million doses of V-RG vaccine have been distributed over > 321,000 square miles in Texas.<sup>c</sup>

During February 2004, a man in Florida, who had recently arrived from Haiti with a history of a dog bite, died of rabies associated with a canine variant of the rabies virus.<sup>f</sup> On May 4, 2004, an organ donor in Arkansas with a history of bat bite died of bat-associated rabies. Four persons who received organs and tissues from this donor subsequently became infected and died from rabies in May and June.<sup>51,52</sup> On October 19, 2004, rabies was diagnosed at the CDC in samples from a teenage girl from Fond du Lac County, Wis.<sup>g</sup> She had been bitten by a bat 1 month earlier. This case is currently under investigation.

These latest cases (n = 7) bring the total number of cases of rabies diagnosed in human beings in the United States since 1990 to 44 (1 case in 2003 was diagnosed in Puerto Rico). Thirty-six (and 1 pending) of these individuals were infected with variants of the rabies virus indigenous to the United States. Monoclonal antibody analysis and genetic sequencing indicated that 34 of these 36 (94.4%) persons were infected with variants of the rabies virus associated with bats (12 of 13 since 2000). Only 5 of these cases involved a report of a definite history of animal bite.

<sup>a</sup>Departamento de Salud, San Juan, Puerto Rico: Notifiable disease report, 2003.

<sup>b</sup>Smith KA, Krogwold R, Collart M, Ohio Department of Health, Columbus, Ohio: Personal communication, 2004.

<sup>c</sup>Wilson PJ, Texas Department of Health, Austin, Tex: Personal communication, 2004.

<sup>d</sup>Fadden D, Massachusetts Department of Public Health, Boston, Mass: Personal communication, 2004.

<sup>e</sup>Lasater R, Tennessee Department of Health, Nashville, Tenn: Personal communication, 2004.

<sup>f</sup>Blackmore C, Florida Department of Health Services, Tallahassee, Fla: Personal communication, 2004.

<sup>g</sup>Kazmierczak J, Wisconsin Department of Health and Family Services, Madison, Wis: Personal communication, 2004.

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