

# Public Veterinary Medicine: Public Health

## Rabies surveillance in the United States during 2002

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**Summary**—During 2002, 49 states and Puerto Rico reported 7,967 cases of rabies in nonhuman animals and 3 cases in human beings to the Centers for Disease Control and Prevention, an increase of 72% from the 7,436 cases in nonhuman animals and 1 case in a human being reported in 2001. More than 92% (7,375 cases) were in wild animals, whereas 7.4% (592) were in domestic species (compared with 93.3% in wild animals and 6.7% in domestic species in 2001). Compared with cases reported in 2001, the numbers of cases reported in 2002 increased among all major reporting groups with the exception of swine and rodents and lagomorphs. The relative contributions of the major groups of animals were as follows: raccoons (36.3%; 2,891 cases), skunks (30.5%; 2,433), bats (17.2%; 1,373), foxes (6.4%; 508), cats (3.8%; 299), dogs (1.2%; 99), and cattle (1.5%; 116). Thirteen of the 19 states in which the raccoon-associated variant of the rabies virus has been enzootic reported increases in the numbers of rabid raccoons during 2002. Among those states that have engaged in wildlife rabies control programs, Ohio reported 1 case of raccoon rabies associated with the epizootic of rabies in raccoons and 1 case in an equid that was infected with a bat variant of the rabies virus, compared with 2 cases reported in terrestrial animals during 2001. Texas reported no cases of rabies associated with the dog/coyote variant of the rabies virus (compared with 1 case in 2001) and 65 cases associated with the gray fox variant of the virus (an increase of 225% from 20 cases reported in 2001). In Massachusetts and Rhode Island, states with enzootic raccoon rabies, reports of rabid skunks again exceeded those of rabid raccoons (the sixth consecutive year, although in Rhode Island, this difference decreased to only 7 more skunks than raccoons [38/31]). Tennessee reported a single case of raccoon rabies in a pet raccoon from the central part of the state; the captive animal had been transported to Tennessee from northern Georgia.

Nationally, the number of rabies cases in skunks during 2002 increased by 6.6% over those reported in 2001. Texas reported the greatest number (740) of rabid skunks and the greatest overall state total of rabies cases (1,049) during 2002. The 1,373 cases of rabies reported in bats during 2002 surpassed the previous year's record (1,281 cases) as the largest number of reported cases ever recorded for this group of mammals. Cases of rabies reported in cats (299), cattle (116), and dogs (99) increased by 10.7%, 41.5%, and 11.24%, respectively, from 2001 to 2002. Rabies among sheep and goats increased 400% from 3 cases in 2001 to 15 in 2002, and cases among horses and mules increased 13.7% (51 cases in 2001 to 58 in 2002). Reported cases of rabies in mongooses in Puerto Rico decreased 4.3% from the previous year (70 cases in 2001 to 67 cases in 2002), while cases of rabies in dogs increased 7.7% (13 to 14). California, Tennessee, and Iowa each reported a case of rabies in a human being during 2002. All cases of rabies in humans were the result of infection with bat variants of the rabies virus.

**I**n the United States and other developed nations, rabies is primarily a disease that affects and is maintained by wildlife populations (Fig 1). During 2002, wild animals accounted for almost 93% of all cases of rabies reported to the Centers for Disease Control and Prevention (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 (Fig 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

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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 canine variant that reemerged in south Texas during the late 1970s and early 1980s have substantially reduced or eliminated the spread of this variant, 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 1990, 27

of 29 human cases (7/7 since 2000) 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>2,5,6</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 inconsequential 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 (Fig 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

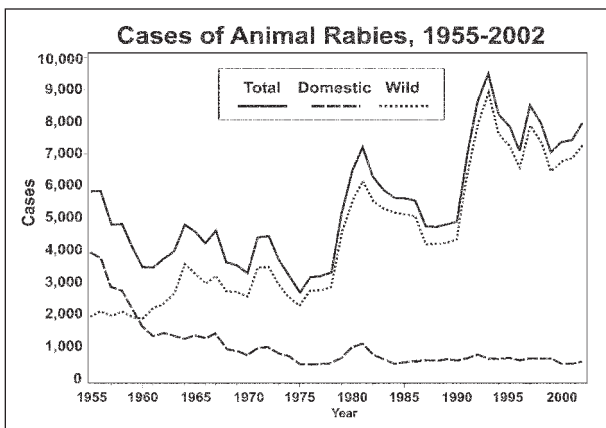


Figure 1—Cases of animal rabies in the United States, by year, 1955 to 2002.

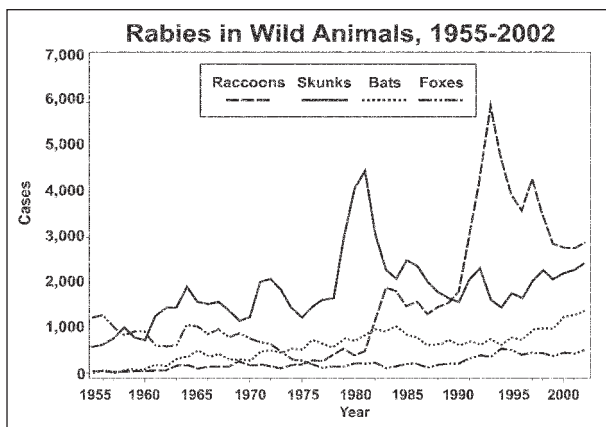


Figure 2—Cases of rabies in wild animals in the United States, by year and species, 1955 to 2002.

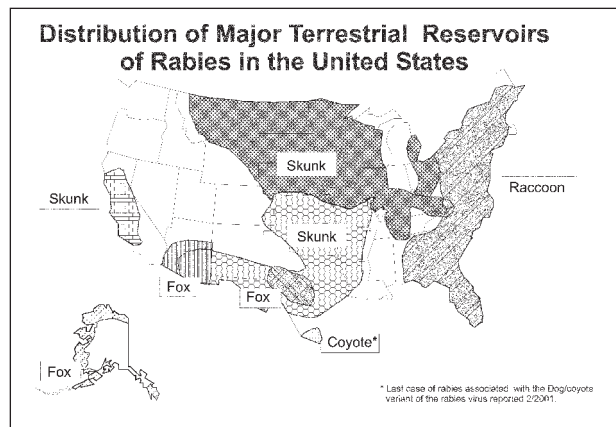


Figure 3—Distribution of major terrestrial reservoirs of rabies in the United States.

Table 1—Cases of rabies in the United States by state and category, 2002

Rabies in the United States, 2002																			
State (City)	Domestic animals										Wild animals					Changes % <sup>§</sup>			
	All animals	Domestic	Wild	Dogs	Cats	Cattle	Horses/ mules	Sheep/ goats	Swine	Other domestic*	Skunks	Foxes	Bats	Raccoons	Rodents/ lagomorphs†		Other wild‡	Human beings	
AL	78	7	71	1	6						2	9	38	21		1 <sup>p</sup>	66	18.18	
AK	27	1	26	1								26					48	-43.75	
AZ	143	4	139	1						3 <sup>a</sup>	44	33	56			6 <sup>q</sup>	129	10.85	
AR	131	7	124	3	3	1					87	2	35				32	309.38	
CA	253	4	248	2	2						62	3	183				322	-21.43	
CO	59	0	59										58			1 <sup>r</sup>	32	84.38	
CT	331	3	328		2			1			104	6	25	183	9 <sup>c</sup>	1 <sup>a</sup>	242	36.78	
DC	11	0	11										3	8			9	22.22	
DE	55	2	53	1	1						4	7	10	32			39	41.03	
FL	181	11	170	3	7		1					29	23	115		3 <sup>t</sup>	209	-13.40	
GA	411	25	386	5	14	6					50	59	26	247	1 <sup>d</sup>	3 <sup>u</sup>	402	2.24	
HI	0	0	0															—	
ID	38	0	38										38				29	31.03	
IL	31	0	31										31				24	29.17	
IN	32	1	31				1				1		30				15	113.33	
IA	79	24	54	3	7	12	2				27		27				85	-7.06	
KS	154	25	129	1	13	3	8				119	1	8	1			100	54.00	
KY	28	6	22	2	2	1		1			17		5				30	-6.67	
LA	6	1	5				1				2		3				10	-40.00	
ME	67	0	67								19	5	6	37			85	-21.18	
MD	396	17	379	1	11	2	3				34	30	35	272	7 <sup>a</sup>	1 <sup>v</sup>	505	-21.58	
MA	303	14	289		11	2		1			141	20	36	85	6 <sup>t</sup>	1 <sup>w</sup>	279	8.60	
MI	46	1	45				1				2		43				47	-2.13	
MN	47	13	34	3	2	6	2				14		20				47	0.00	
MS	4	0	4										4				4	0.00	
MO	46	2	44		1	1					14		30				40	15.00	
MT	21	3	18		2	1					8		10				36	-41.67	
NE	27	3	24		2	1					3	3	18				12	125.00	
NV	17	0	17										2	15			5	240.00	
NH	47	2	45		1	1					11	2	2	26	4 <sup>g</sup>		25	88.00	
NJ	213	18	195	1	17						28	3	39	118	6 <sup>h</sup>	1 <sup>x</sup>	200	6.50	
NM	10	3	7	2			1				3		4				15	-33.33	
NY	705	47	658	3	30	12	2				172	38	96	339	8 <sup>i</sup>	5 <sup>y</sup>	783	-9.96	
NYC	27	1	26		1						4		6	16			38	-28.95	
NC	706	45	661	10	28	4	3				116	48	36	455		6 <sup>z</sup>	571	23.64	
ND	59	19	40	2	4	11	1	1			39			1			42	40.48	
OH	39	1	38				1						37	1			52	-25.00	
OK	126	25	101	9	7	4	5				92	1	8				60	110.00	
OR	14	0	14										2	12			4	250.00	
PA	496	53	443	2	42	5	3		1 <sup>b</sup>		86	29	32	289	4 <sup>j</sup>	3 <sup>aa</sup>	441	12.47	
PR	87	20	67	14	1	1	4									67 <sup>bb</sup>	98	-11.22	
RI	83	2	81		2						38	7	3	31	2 <sup>k</sup>		72	15.28	
SC	162	16	146		15		1				17	29	8	90		2 <sup>cc</sup>	143	13.29	
SD	96	28	68	8	6	8	4	2			59		9				58	65.52	
TN	111	3	107	2		1					77	2	27	1			106	4.72	
TX	1,049	72	977	15	24	21	5	7			740	48	167	12		10 <sup>dd</sup>	1,043	0.58	
UT	13	0	13										13				15	-13.33	
VT	91	6	85		2	1	3				13	3	2	67			62	46.77	
VA	592	46	546	4	27	9	3	3			147	56	17	318	3 <sup>m</sup>	5 <sup>ee</sup>	502	17.93	
WA	13	1	12		1								12				22	-40.91	
WV	175	8	167		4	2	2				24	5	8	126	2 <sup>n</sup>	2 <sup>ff</sup>	142	23.24	
WI	16	2	14		1		1				4		10				20	-20.00	
WY	18	0	18								9		9				40	-55.00	
<b>Total</b>	<b>7,970</b>	<b>592</b>	<b>7,375</b>	<b>99</b>	<b>299</b>	<b>116</b>	<b>58</b>	<b>15</b>	<b>1</b>	<b>4</b>	<b>2,433</b>	<b>508</b>	<b>1,373</b>	<b>2,891</b>	<b>52</b>	<b>118</b>	<b>3</b>	<b>7,437</b>	<b>7.17</b>
% 2002	100.00	7.43	92.53	1.24	3.75	1.46	0.73	0.19	0.01	0.05	30.53	6.37	17.23	36.27	0.65	1.48	0.04		
Total 2001¶	7,437	497	6,939	89	270	82	51	3	2	0	2,282	437	1,281	2,767	56	116	1		
% change§	7.17	19.11	6.28	11.24	10.74	41.46	13.73	400.00	-50.00	—	6.62	16.25	7.18	4.48	-7.14	1.72	200.00		

\*Other domestic includes: <sup>a</sup>3 lamas; <sup>b</sup>1 ferret. †Rodents and lagomorphs include: <sup>c</sup>9 groundhogs; <sup>d</sup>1 beaver; <sup>e</sup>7 groundhogs; <sup>f</sup>6 groundhogs; <sup>g</sup>4 groundhogs; <sup>h</sup>6 groundhogs; <sup>i</sup>8 groundhogs; <sup>j</sup>4 groundhogs; <sup>k</sup>2 groundhogs; <sup>l</sup>1 rabbit, 2 groundhogs; <sup>m</sup>1 beaver, 1 groundhog. ‡Other wild includes: <sup>n</sup>1 bobcat; <sup>o</sup>2 coyotes, 3 bobcats, 1 javelina; <sup>p</sup>1 bobcat; <sup>q</sup>1 coyote; <sup>r</sup>3 bobcats; <sup>s</sup>3 bobcats; <sup>t</sup>1 deer; <sup>u</sup>1 fisher; <sup>v</sup>1 deer; <sup>w</sup>5 deer; <sup>x</sup>6 bobcats; <sup>y</sup>1 otter, 2 deer; <sup>z</sup>67 mongooses; <sup>aa</sup>2 bobcats; <sup>ab</sup>2 bobcats; <sup>ac</sup>1 wolf/hybrid, 7 bobcats, 1 javelina, 1 coyote; <sup>ad</sup>5 bobcats; <sup>ae</sup>2 bobcats. ||Percentage of all rabid animals in 2002. ¶2001 total by species. §Percentage change from 2001.

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 1950s to affect foxes across Canada and, intermittently, foxes in adjoining areas of the New England states. Rabies persists in foxes in Alaska, while

reports of rabid foxes have declined in Canada. Two different variants of rabies virus are present in geographically limited populations of gray foxes (*Ucinereoargenteus*) 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 of rabies associated with the dog/coyote variant of the rabies virus have been reported since February 2001.

The use of population-reduction programs to control rabies among wild terrestrial carnivores is not desirable nor has such an undertaking 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 numbers 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 (V-RG)** 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 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.

Short-term trends are determined by comparing reported cases from 2002 with those from 2001 and by examining seasonal patterns for selected species.

Summaries of 2002 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 CDC during 2003 is also included.

## Collection of Data

Data collection procedures were similar to those described previously.<sup>2</sup> Between January 1 and December 31, 2002, all 50 states, 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 (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 (RT-PCR)** assays were used to confirm some cases.

## Rabies in Wild Animals

Wild animals accounted for more than 92.5% of the 7,970 reported cases of rabies in 2002 (Fig 1). The 7,375 cases reported among wildlife in 2002 were a 6.3% increase over the 6,939 cases reported in 2001 (Table 1). Raccoons continued to be the most frequently reported rabid wildlife species (36.3% of all animal cases during 2002), followed by skunks (30.5%), bats (17.2%), foxes (6.4%), and other wild animals including rodents and lagomorphs (2.1%). Numbers of reported cases in foxes, bats, skunks, and raccoons increased 16.3%, 7.2%, 6.6%, and 4.5%, respectively, over 2001 totals.

**Raccoons**—The 2,891 cases of rabies in raccoons (*P. lotor*) reported in 2002 marked the end of 5 consecutive years of decreased numbers in this species (Fig 2 and 4). Increases in numbers of rabid raccoons during 2002 were reported by 13 of the 19 eastern states in which raccoon rabies has been enzootic, including Connecticut (36.6% increase; 134 cases in 2001 to 183 in 2002), Delaware (23.1%; 26 to 32), Georgia (8.3%;

228 to 247), Maine (8.8%; 34 to 37), Massachusetts (3.7%; 82 to 85), New Hampshire (225.0%; 8 to 26), North Carolina (17.9%; 386 to 455), Pennsylvania (18.4%; 244 to 289), Rhode Island (40.9%; 22 to 31), South Carolina (12.5%; 80 to 90), Vermont (67.5%; 40 to 67), Virginia (10.4%; 288 to 318), and West Virginia (31.3%; 96 to 126) (Fig 4 and 5; Table 1).<sup>2,8-11,15,23</sup> Five states with enzootic raccoon rabies reported decreases in numbers of rabid raccoons, including Alabama (4.5% decrease), Florida (11.5%), Maryland (25.7%), New Jersey (1.0%), and New York (18.3%), as well as New York City (44.8%). The District of Columbia (8 cases) and Ohio (1 case) reported no change in numbers of rabid raccoons for 2002.

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, West Virginia, and the District of Columbia and New York City, accounted for 67.4% (1,948 cases) of the total rabies cases in raccoons in 2002, whereas the southeastern states of Alabama, Florida, Georgia, North Carolina, and South Carolina reported 32.1% (928) of the total cases in raccoons.

Ohio reported a single case of rabies in a raccoon infected with the raccoon variant of the rabies virus. Kansas reported 1 case of rabies in a raccoon infected

with a skunk variant of the rabies virus. Tennessee reported 1 case of raccoon rabies in a raccoon from centrally located Coffee County. The raccoon was a captive pet that had been transported to Tennessee from northern Georgia and was tested for rabies because of odd behavior. Rabid raccoons reported by Texas (12 cases) 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). Other than the rabid raccoon reported by Ohio, states west of the Ohio River in the North and west of the Appalachian Mountains in the South remained free of rabies associated with the epizootic in raccoons during 2002. The rabid raccoon reported by Tennessee was regarded as an isolated, translocated case of raccoon rabies and as such did not represent expansion of the epizootic of rabies in raccoons into the state of Tennessee.

**Skunks**—The 2,433 reported cases of rabies in skunks (mainly *M. mephitis*) in 2002 were a 6.6% increase over those reported in 2001 (Fig 6; Table 1). Twenty-five of 36 states reported increases in numbers of rabid skunks. Texas reported the greatest number of rabid skunks (740) and the greatest overall state total of rabies cases (1,049) during 2002. Arkansas reported an increase of 210.7% (28 cases in 2001 to 87 cases in 2002). Wisconsin was the only other state that reported an increase of > 100% (300% [1 case in 2001 to 4 cases in 2002]). Indiana (1 case) and Michigan (2 cases) reported rabies in skunks during 2002, but did not report rabies in skunks during 2001. Eleven states reported decreases in numbers of rabid skunks in 2002. Only California (58.9% [151 to 62 cases]), Louisiana (60.0% [5 to 2]), Montana (52.9% [17 to 8]), and Wyoming (66.7% [27 to 9]) reported decreases of > 50% compared with cases reported in 2001. Every state that reported rabid skunks in 2001 also reported rabid skunks in 2002. States in which the raccoon-associated variant of the rabies virus is enzootic reported 41.5% (1,010/2,433) of the cases of rabies in skunks, the majority of which were presumably the result of spillover transmission of virus from raccoons. Massachusetts (141 cases) and Rhode Island (38) each reported more rabid skunks than rabid raccoons for a sixth consecutive year.

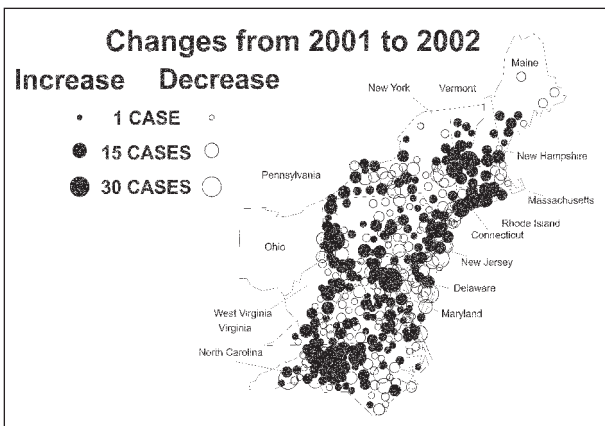


Figure 4—Changes in cases of rabies in raccoons in the mid-Atlantic and northeastern states, 2001 to 2002. Dot size is proportional to the number of cases in the county.

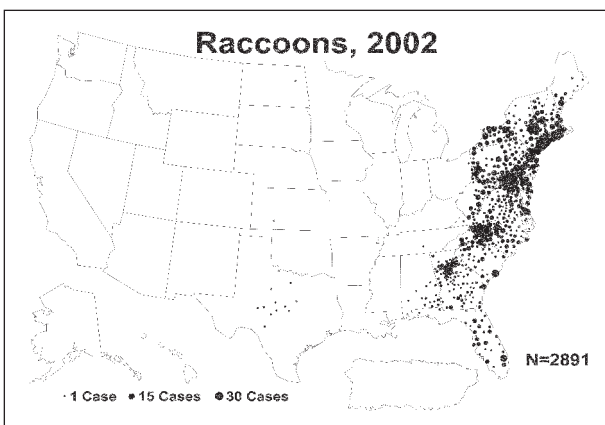


Figure 5—Reported cases of rabies in raccoons, by county, 2002.

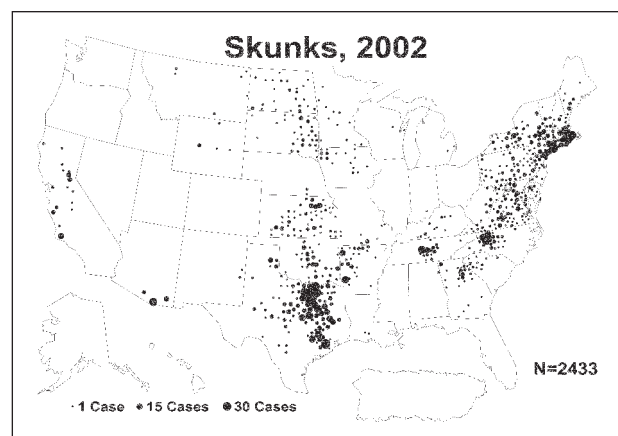


Figure 6—Reported cases of rabies in skunks, by county, 2002.

**Bats**—Rabies in bats accounted for 17.2% of all cases of rabies in animals reported in 2002 (Table 1). The 1,373 cases were the largest number ever reported and represented a 7.2% increase over the total reported in 2001. Rabies in bats is widely distributed throughout the United States, with cases reported from 47 of the 48 contiguous states (Fig 7). During 2002, California reported the largest number of cases (183), followed by Texas (167) and New York (96). Four states (Idaho, Illinois, Mississippi, and Utah) reported rabies in bats but not in terrestrial mammals. Alaska, Hawaii, North Dakota, and Puerto Rico did not report any cases of rabies in bats.

Of the bats positive for rabies virus, 56.9% (781/1,373) were identified beyond the taxonomic level of order (12 to genus, 769 to species). Among bats identified to species level, 46.3% (356/769) were *Eptesicus fuscus*, the big brown bat; 27.0% (208/769) were *Tadarida brasiliensis*, the Brazilian (Mexican) free-tailed bat; 7.5% (58/769) were *Lasiurus cinereus*, the hoary bat; 6.0% (46/769) were *L borealis*, the red bat; 3.1% (24/769) were *M lucifugus*, the little brown bat; 2.6% (20/769) were *Lasionycteris noctivagans*, the silver-haired bat; 2.1% (16/769) were *Pipistrellus hesperus*, the western pipistrelle; 1.2% (9/769) were *Myotis yumanensis*, the Yuma bat; and 0.7% (5/769) were *P subflavus*, the eastern pipistrelle. Unspecified bats of the genus *Myotis* (1.2% [9/781]) and the genus *Tadarida* (0.4% [3/781]) and 10 other species (contributing < 3.6% [27/769] to the total, with no individual species in this latter group contributing > 0.8%) accounted for the remaining rabid bats. Not all states were able to specify bats nor did all states report total numbers of bats tested for rabies.

**Foxes**—Foxes (mainly *V vulpes*) accounted for 6.4% of all cases of rabies in animals reported in 2002 (Table 1). The 508 cases of rabies in foxes were a 16.3% increase over 2001, and the majority (385) were reported by states affected by the raccoon-associated variant of the rabies virus (Fig 8). Arizona (33 cases), Massachusetts (20), Texas (48), and Virginia (56) reported increases of 27, 10, 33, and 22 cases, respectively, over 2001. Alaska (26 cases), Florida (29), Maryland (30), and North Carolina (48) reported decreases of 19, 6, 8, and 8 cases, respectively. Most cases of rabies in foxes reported by eastern states were

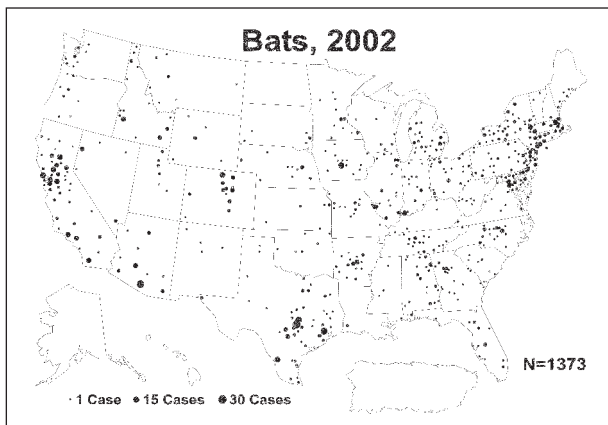


Figure 7—Reported cases of rabies in bats, by county, 2002.

probably caused by the rabies virus variant associated with raccoons, with the possible exception of Maine, New York, and Vermont. Rabies in gray foxes in Arizona and Texas is usually (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 (2 cases), New Hampshire (2), Oklahoma (1), Oregon (2), and Tennessee (2) reported rabid foxes in 2002 but did not report rabid foxes in 2001, whereas Iowa, Kentucky, Michigan, Missouri, and Wyoming reported rabid foxes in 2001 but not in 2002.

**Other wild animals**—Puerto Rico reported 67 rabid mongooses (*Herpestes javanicus*) during 2002, a 4.3% decrease from the 70 cases reported in 2001 (Fig 9). Other wildlife in which rabies was reported included 49 groundhogs (*Marmota monax*), 33 bobcats (*Lynx rufus*), 9 deer (*Odocoileus virginianus*), 4 coyotes (*C latrans*), 2 beavers (*Castor canadensis*), 1 fisher (*Martes pennanti*), 1 javelina (*Pecari tajacu*), 1 otter (*Lontra canadensis*), 1 rabbit (*Oryctolagus cuniculus*), and 1 wolf-dog hybrid (feral *C lupus* × *C lupus [familiaris]*).<sup>24</sup> All cases of rabies in rodents and lagomorphs (primarily groundhogs, 49/52 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 (Fig 9, Table 1).

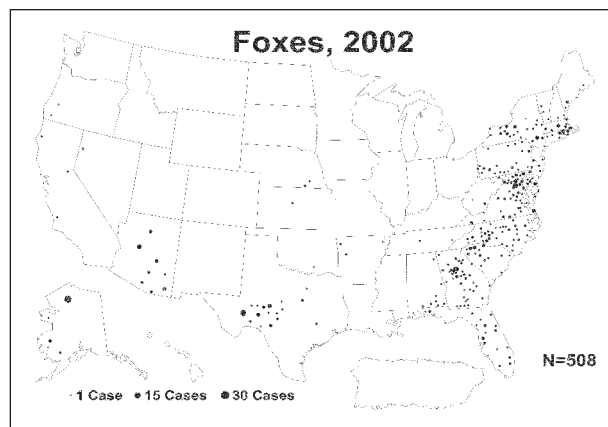


Figure 8—Reported cases of rabies in foxes, by county, 2002.

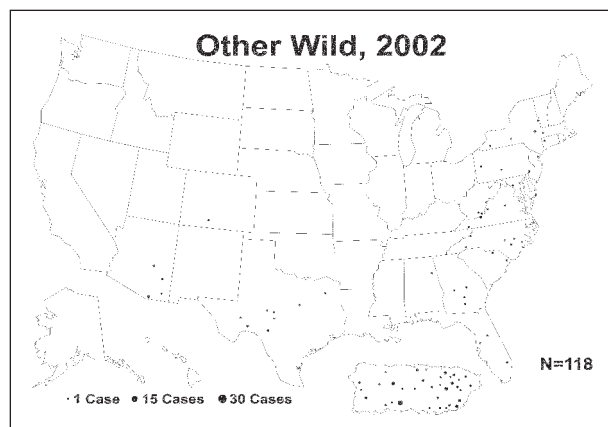


Figure 9—Reported cases of rabies in "Other wild" category of Table 1, by county and municipio (Puerto Rico), 2002.

## Rabies in Domestic Animals

Domestic species accounted for 7.4% of all rabid animals reported in the United States in 2002 (Table 1). The number of domestic animals reported rabid in 2002 (592) represented a 19.1% increase over the total reported in 2001 (Fig 10). Cases of rabies reported in cats, cattle, and dogs increased 10.7%, 41.5%, and 11.2%, respectively, compared with totals reported in 2001. Texas reported the largest number of rabid domestic animals (72 cases), followed by Pennsylvania (53), New York (47), and 1 case reported by New York City, and Virginia (46).

**Cats**—The majority (221) of the 299 cases of rabies in cats was reported from states in which the raccoon-associated variant of the rabies virus is present (Fig 11). 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. Eleven states reported > 10 cases of rabies in cats (Pennsylvania, 42; New York, including New York City, 31; North Carolina, 28; Virginia, 27; Texas, 24; New Jersey, 17; South Carolina, 15; Georgia, 14; Kansas, 13; Maryland, 11; and Massachusetts, 11). Eighteen states and the District of Columbia did not report any rabid cats.

**Dogs**—Texas (15 cases), Puerto Rico (14), North Carolina (10), Oklahoma (9), and South Dakota (8)

reported the largest numbers of cases of rabies in dogs by individual states or territories in 2002. 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 (Fig 12; Table 1). Other than Georgia (5 cases) and Virginia (4), no other state reported > 3 cases of rabies in dogs in 2002. 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 increased from 82 in 2001 to 116 in 2002 (Fig 13; Table 1). Distribution of rabid cattle was similar to that of rabid skunks in the central and midwestern states (Fig 6 and 13) and to rabid raccoons in the mid-Atlantic/northeastern region (Fig 5 and 13). Texas (21 cases), Iowa (12), New York (12), North Dakota (11), Virginia (9), and South Dakota (8) reported the largest numbers of rabid cattle. No other state reported > 6 cases of rabies in cattle. The 58 cases of rabies reported in horses and mules (including donkeys) in 2002 represented a 13.7% increase over the 51 cases reported during 2001. Other reported cases of rabies in domestic animals included 12 goats (a 300% increase, compared with 3 in 2001), 3 sheep, and 1 swine.

## Seasonal Trends

The frequency of reported cases of rabies in raccoons was high from March to May, followed by an

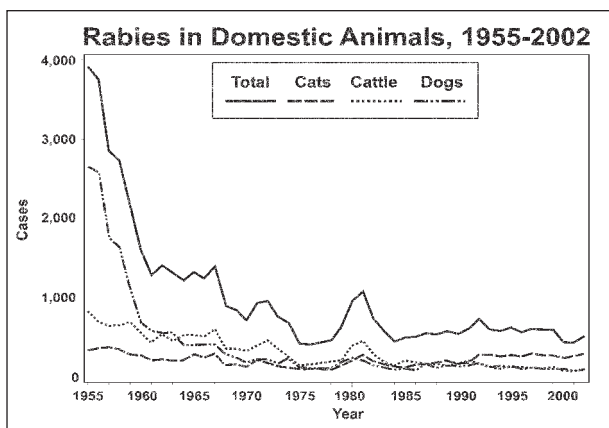


Figure 10—Cases of rabies in domestic animals in the United States, by year, 1955 to 2002.

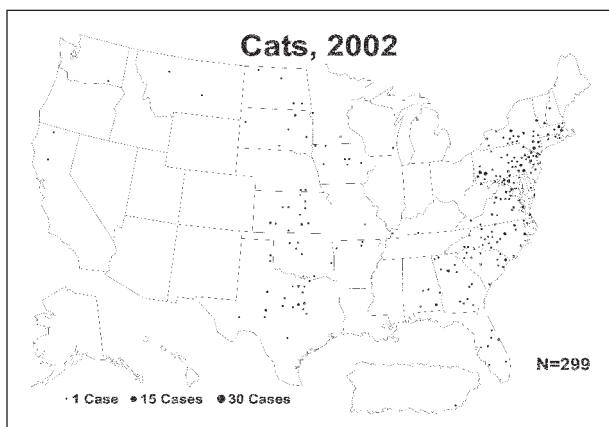


Figure 11—Reported cases of rabies in cats, by county and municipio (Puerto Rico), 2002.

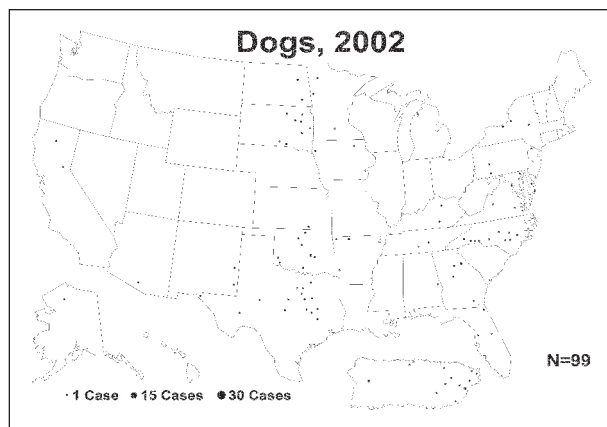


Figure 12—Reported cases of rabies in dogs, by county and municipio (Puerto Rico), 2002.

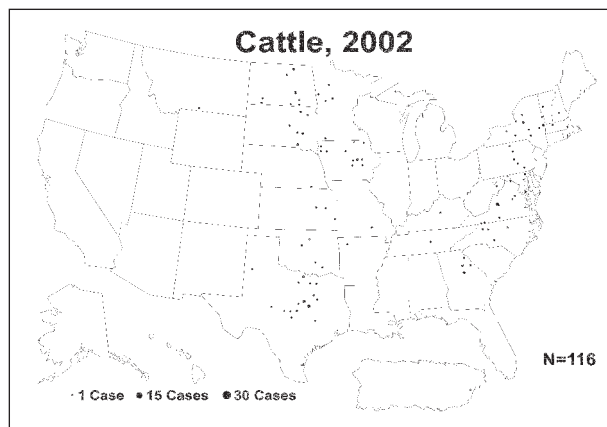


Figure 13—Reported cases of rabies in cattle, by county, 2002.

undulating but gradual decline to a December low (Fig 14). The frequency of reporting for rabid skunks showed a March-April peak, followed by a decline into the summer months prior to an increase to a lower peak spanning the period from August to October. 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 peak in July, followed by a drop in August and gradual further decline to a low in November.

Reports of rabid cats rose steeply to a peak in May, then declined only slightly into August before dropping precipitously in September (Fig 15). This autumnal decline was followed by an increase to a lower October-November reporting peak and then a second sharp decline to a December low. Reports of rabies cases in dogs fell sharply in March before rising to an April peak. Reports then declined through the summer before increasing slightly during the late fall and early winter. Reported cases in cattle fell from a January high, showing no clear patterns throughout the remainder of the year, prior to rising sharply to a second high in December (Fig 15).

### Rabies in Human Beings

Three cases of rabies in human beings were reported in the United States during 2002 (Table 2).<sup>2,26-28</sup>

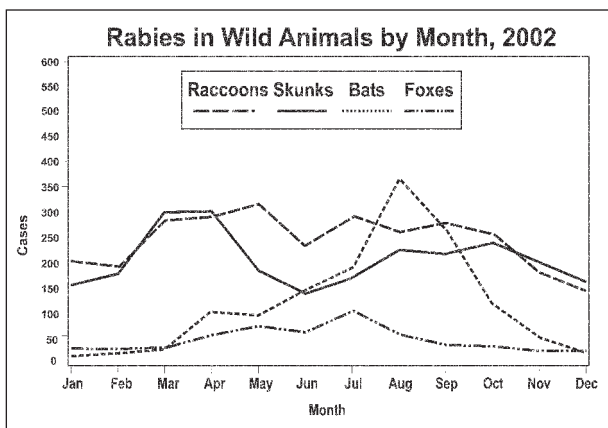


Figure 14—Cases of rabies in wild animals in the United States, by month, 2002.

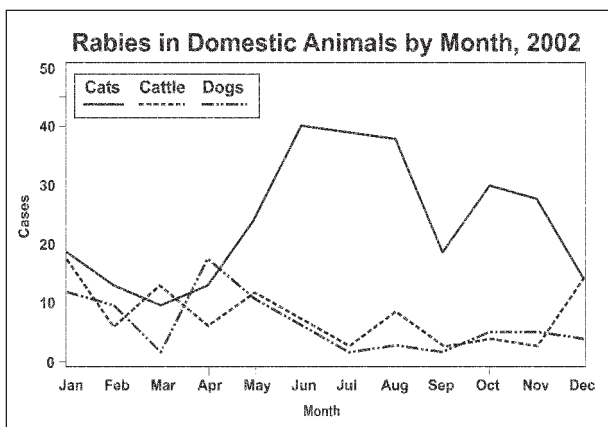


Figure 15—Cases of rabies in domestic animals in the United States, by month, 2002.

On March 31, 2002, a 28-year-old man residing in Glenn County, Calif, died from rabies. The man went to an emergency department (ED) on March 18 with headache, jaw pain, photophobia, agitation, dizziness, nausea, and vomiting. He was treated for dehydration and released. He returned the following day with increases in the symptoms mentioned and with tingling of the head and legs. He was admitted, and during his 12-day hospitalization, the patient's status deteriorated with symptoms of a rapidly progressing encephalopathy and also included fever, incoherent speech, increased agitation, and copious salivation. Results of blood work and computed tomography scan were unremarkable. He became comatose, was placed on ventilatory support, and died on March 31 following withdrawal of life support. Rabies had been presumptively diagnosed by the use of corneal impressions and a saliva sample on March 29 and was confirmed on April 1 with a saliva sample that was positive by RT-PCR. The virus was identified as a variant associated with the Mexican free-tailed bat (*T brasiliensis*). The patient's family reported that he had killed a bat at his house on March 10, although he had denied having any direct contact with

Table 2—Cases of rabies in human beings in the United States and Puerto Rico, 2000 through September 2003\*, 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	Dog bite-Ghana	Dog, Africa
10 Oct 00	GA	Unknown†	Bat, Tb
25 Oct 00	MN	Bat 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 United States
5 Jun 03	PR	Bite	Dog/mongoose, Puerto Rico
14 Sep 03	CA	Bite	Bat, Ln/Ps

\*All laboratory-confirmed cases of rabies in human beings who developed the disease in the United States and Puerto Rico, 2000–2003. \*\*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). †In some instances where the exposure history is unknown, there may have been known or inferred interaction which, especially for bats, could have involved an unrecognized bite. ‡ 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 bat(s) 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.



the animal. Health department investigation revealed a bat colony in the attic of the house.<sup>26</sup>

On August 31, 2002, a 13-year-old boy residing in Franklin County, Tenn, died from rabies. On August 21, a prodrome of symptoms began with headache, neck pain, right arm numbness and weakness, and a fever of 37.7°C (100°F). Because of these symptoms, the patient was taken to a hospital ED on August 24, where diplopia and muscle strain were diagnosed and he was released. The patient returned on August 25 with symptoms that included fever of 38.8°C (102°F), right arm weakness, slurred speech, nuchal rigidity, and dysphagia. Results of blood work and computed tomography scan were unremarkable, and the patient was transferred to a regional children's hospital. On August 26, he had difficulty breathing because of decreased mental status and hypersalivation. He was intubated, mechanically ventilated, and sedated because of agitation. Rabies was suspected on the basis of neurologic symptoms and hypersalivation and confirmed on August 30 by detection of virus in serum and cerebral spinal fluid on August 30. On August 31, the patient was pronounced brain dead; support was withdrawn, and the patient died. The boy's parents reported that the patient had found a bat on the ground on approximately July 1, brought it home, and released it in a nearby woods. The boy had never mentioned being bitten. The virus was identified as a variant associated with the silver-haired (*L noctivagans*) and eastern pipistrelle (*P subflavus*) bats.<sup>27</sup>

On September 28, 2002, a 20-year old man residing in Linn County, Iowa, died from rabies. On September 16, the man went to an ED because of nausea, vomiting, generalized abdominal pain, shortness of breath, headache, and back stiffness. He had been consuming beer heavily and was concerned about alcohol poisoning. The man was treated with an antiemetic and released. He returned the next day complaining of the same symptoms and was noted to be hostile, paranoid, and hallucinating. He was admitted with a diagnosis of a suspected drug reaction or withdrawal syndrome. Magnetic resonance imaging and electroencephalogram results were unremarkable. His condition deteriorated with the development of a fever of 38.6°C (101.5°F), tremors, and intractable seizure. The patient required intensive care, and on September 19, he was placed on ventilator support. On September 23, the patient had evidence of neurologic impairment and unreactive pupils. Surgery was performed to relieve intracranial pressure, and a brain biopsy sample was taken. On September 28, ventilator support was withdrawn and the patient died. A nuchal biopsy sample obtained on September 27 was positive by DFA staining for rabies virus antigen and by RT-PCR assay for rabies virus RNA. The patient had been bitten by a dog approximately 12 days before admission, but the animal was determined not to have been capable of transmitting rabies virus. The virus was identified as a variant associated with the silver-haired (*L noctivagans*) and eastern pipistrelle (*P subflavus*) bats. No evidence of bat infestation in the patient's home was found, and family and friends did not recount any contact with or bites from bats.<sup>28</sup>

## Rabies in Canada and Mexico

Canada reported 343 laboratory-confirmed and 6 clinically diagnosed cases of rabies in domestic and wild animals in 2002. This number represented a 21.6% decrease from the 445 rabies cases reported in 2001. Much of the decrease was attributable to fewer reported cases of rabies in raccoons. Reported cases of rabies in raccoons decreased 70.8% (26 cases in 2002, compared with 89 in 2001) and accounted for 7.5% (26/349) of all rabid animals reported in 2002 (the first decrease in reports of rabies in raccoons in Canada since the entrance of the epizootic of rabies more than 4 years earlier).

Reported cases of rabies in skunks in Canada decreased 19.2% (from 125 cases in 2001 to 101 in 2002) and accounted for 28.9% of all rabid animals reported in 2001. Reported cases of rabies in bats increased 8.7% (112 cases in 2002, compared with 103 in 2001) and accounted for 32.1% of all reported cases of rabies. Other noteworthy contributions to the 2002 Canadian total included foxes (18.6%), cattle (5.2%), dogs (2.3%), and equids (1.2%). Canada did not report any cases of rabies in human beings during 2002.

Mexico reported 331 laboratory-confirmed cases of rabies in domestic and wild animals during 2002. This total represented a 6.5% decrease from the 354 cases reported in 2001. Dogs accounted for 31.7% (105/331) of reported cases of rabies, a decrease of 10.3% from 2001 (117 cases). The other reported rabid animals included 191 cattle, 8 bats, 6 cats, 7 skunks (several species), 4 equids, 4 foxes, 2 goats, 2 wild cats (presumably bobcats [*L rufus*]), 1 puma (*Puma concolor*), and 1 sheep. Two cases of rabies were reported in human beings, a 71.4% decrease from 2001 (7 cases). Source animals implicated in the exposure of the human beings were bats.

## Discussion

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.

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>

The number of cases of rabies in raccoons increased during 2002, following 5 consecutive years of decline. Raccoons continued to account for the highest percentage (36.3%) of rabies cases reported among animals in the United States in 2002; however, the magnitude of this ratio continues to decline (Fig 2). Enzootic transmission of rabies among raccoons was apparent in 19 states and the District of Columbia in 2002 (a single case of rabies in a raccoon infected with the raccoon variant of the rabies virus

was reported by Ohio during 2002). Although Tennessee reported a single case of raccoon rabies in a pet raccoon from the central part of the state, the captive animal was determined to have been transported to Tennessee from northern Georgia and, as such, was an isolated incident that was not representative of indigenous enzootic raccoon rabies. States in the affected area reported 99.5% (2,876/2,891) of all documented cases of rabies in raccoons and accounted for 67.3% (5,365/7,970) of the total cases of rabies reported in the United States during 2002. 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 V-RG vaccine was conditionally licensed in April 1995 and 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, and West Virginia.

During 2002, multiple state agencies, the CDC, and the US Department of Agriculture continued partnerships and cooperation in a massive undertaking to maintain and expand an "immune barrier" by use of **oral rabies vaccine (ORV)** from the shores of Lake Erie in Ohio, Pennsylvania, and New York that is destined to eventually reach the Gulf of Mexico in Alabama. Ohio rebaited a 9-county area, including 4 counties bordering Pennsylvania during the spring and fall.<sup>31,32,a</sup> Also during the fall of 2002, ORV baits were distributed in 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>31,33</sup> These ORV programs during 2002 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. 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 increased by 6.6% over those reported in 2001, and, in contrast to 2001, 25 of the 36 states that reported rabid skunks (a clear majority) reported increases in numbers of rabid skunks. However, Arkansas and Wisconsin were the only states that reported increases of > 100%, and in Wisconsin,

actual numbers were small. No rabid skunks were reported from the Flagstaff area (erroneously reported as the "Phoenix area" in the last year's report). While Texas reported the greatest number of rabid skunks during 2002, the 740 cases of rabies in skunks were 38 fewer than those reported in 2001. Ten other states reported decreases in numbers of rabid skunks in 2002, and of those, only 4 reported decreases of > 50%, compared with cases reported in 2001. Every state that reported rabid skunks in 2001 also reported rabid skunks in 2002. Massachusetts (141 cases) and Rhode Island (38) each reported more rabid skunks than rabid raccoons for the sixth 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 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 is likely that < 60% of all reported skunks (those reported rabid in areas previously defined) are infected with variants of the rabies virus maintained by skunk reservoirs.

Cases of rabies in foxes in 2002 increased 6.4% over numbers for 2001. 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 was observed during 2002; however, no infections occurred outside of the boundaries of the original containment area.<sup>b</sup> Fifteen states reported increases in reported cases of rabies in foxes. Although increases were usually small, Arizona (33 cases) and Texas (48) reported increases of 450% and 220%, respectively. In contrast, 11 states reported decreases, which were also usually small, in numbers of rabid foxes. Florida, Maryland, North Carolina, and Pennsylvania reported decreases of 6, 8, 8, and 5 cases, respectively; only Alaska (19 fewer cases than in 2001) reported a decrease of > 8 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 beavers during 2002).<sup>40</sup> Large species of rodents and lagomorphs, or those kept in outdoor cages, may become infected and survive long enough to pose a risk to other species (1 case in a rabbit during 2002). 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 (2.7 million baits delivered over 33,000 square miles) were completed during 2002 in Texas to interrupt the transmission of rabies virus in gray foxes and in dogs and coyotes.<sup>18,41,42,b</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 7.4% in 2002. Reported cases of rabies in dogs (99), cats (299), and cattle (116) increased by 11.2%, 10.7%, and 41.5%, respectively; the record lows for cattle and dogs reported in 2001 could not be repeated or outdone. The number of cases of rabies reported in cats was more than 3 times that reported for dogs and more than twice the number reported for cattle, and it was more than the combined total number of cases reported for dogs and cattle. The number of cases among sheep and goats increased from a remarkably low 3 cases (representing goats only) in 2001 to 15 cases of rabies in this group for 2002. Cases of rabies among horses and mules increased 13.7% (51 cases in 2001 to 58 cases in 2002). Only Kansas (8 cases), Oklahoma (5), and Texas (5) 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 variants of the rabies virus responsible for cases of rabies reported in cats and dogs and assess what contribution, if any, was the result of bat-associated variants of the rabies virus.<sup>43</sup> Nearly all animals (229 cats and 78 dogs) were infected via spillover with the predicted terrestrial variant of the rabies virus; that is, 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 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> While 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 2002, the total number of cases of rabies diagnosed in human beings in the United States since 1990 increased to 36. Seven (19.4%) of these 36 individuals were infected outside the United States. Human rabies cases that are the result of infections that occur abroad usually occur in developing nations where rabies is enzootic, involves regional canine variants of the rabies virus, and in 5 of 7 such cases involved had a reported history of dog bite. Twenty-nine (80.6%) of the 36 individuals were infected with variants of the rabies virus indigenous to the United States. Monoclonal antibody analysis and genetic sequencing indicated that 27 of these 29 (93.1%) persons were infected with variants of the rabies virus associated with bats (7/7 since 2000; Table 2).<sup>2,5,6</sup> Although infection of human beings with rabies virus from bats is a rare occurrence, the prevention of such infection remains an important public health concern.<sup>39</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.

## 2003 Rabies Update

During the first 9 months of 2003, 2 cases of rabies were reported that were attributable to infection with the raccoon variant of the rabies virus in Ohio, and both occurred in raccoons. 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 state-wide passive surveillance system. The 4 cases of raccoon rabies reported by Ohio during 2001–2003 very near the Pennsylvania border serve as a reminder that immune corridors will not remain so without continued vigilance as well as cooperation and participation with neighboring states. In Ohio, > 638,000 additional doses of ORV baits were distributed during the late summer-fall of 2003 over a total of 3,100 square miles in 9 eastern Ohio counties.<sup>49,a</sup>

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 western-most Virginia, and currently terminating in the eastern corner of Tennessee.<sup>33,50</sup> Rabid raccoons have been reported in several counties in north-

ern Georgia, very close to the Tennessee border, and in several counties in western-most Virginia, adjacent Kentucky and Tennessee. Tennessee reported its first case of rabies in a raccoon indigenously infected with the raccoon variant of the rabies virus from the remote northeastern part of the state (additional cases [2 raccoons, 1 cat] have been reported). Thus, raccoon rabies may soon be detected in Kentucky. The risk of introduction of the raccoon-associated variant of the rabies virus and continued expansion of the epizootic of rabies in raccoons into these and other midwestern states remains a major concern.

In Texas, an additional 2.5 million doses of V-RG vaccine were distributed over 31,000 square miles during 2003. During the first 9 months of 2003, no cases of rabies attributable to the dog/coyote variant of the rabies virus were reported in Texas. During this same period, 50 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 20 million doses of V-RG vaccine have been distributed over 286,000 square miles in Texas.<sup>b</sup> By the end of 2003, at least 15 states, including Alabama, Florida, Georgia, Maine, Maryland, Massachusetts, New Hampshire, New York, Ohio, Pennsylvania, Tennessee, Texas, Vermont, Virginia, and West Virginia, will have distributed oral rabies vaccine baits.

On January 30, 2003, a 52-year-old man from the greater Vancouver region of British Columbia, Canada, died from undiagnosed rabies encephalitis caused by a bat-associated rabies virus. More than 450 persons were given rabies postexposure prophylaxis because of known or possible exposure to this patient.<sup>51</sup> Canadian officials responsible for animal rabies surveillance indicate that the area of Ontario affected by the epizootic of rabies in raccoons has stabilized, and that ORV programs are viewed as being in great part responsible for this success. The state of Maine and the province of New Brunswick are partnering in efforts to stop the spread of raccoon rabies. Rabies activity associated with the second focus of the raccoon rabies epizootic in Canada that originated from the state of Maine and entered Canada via New Brunswick has diminished substantially in 2003.<sup>52,53</sup>

Three cases of rabies in human beings that were caused by 3 variants of the rabies virus have been reported to CDC in 2003.

On March 10, 2003, a 25-year-old man residing in Fairfax County, Va, died of rabies encephalitis. The variant of the rabies virus that caused this infection 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 no history of animal bite or exposure could be elicited from friends and relatives.<sup>c</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 [famil-*

*iaris*]) 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>d</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>e</sup>

These latest cases bring the total number of cases of rabies diagnosed in human beings in the United States since 1990 to 38 (1 case in 2003 was diagnosed in Puerto Rico). Thirty-one of these individuals were infected with variants of the rabies virus indigenous to the United States. Monoclonal antibody analysis and genetic sequencing indicated that 29 of these 31 (93.5%) persons were infected with variants of the rabies virus associated with bats. Only 3 of these cases involved a report of a definite history of animal bite.

<sup>a</sup>Smith KA, Krogwold R, Collart M, Ohio Department of Health, Columbus, Ohio: Personal communication, 2003.

<sup>b</sup>Wilson PJ, Texas Department of Health, Austin, Tex: Personal communication, 2003.

<sup>c</sup>Jenkins SR, Virginia Department of Public Health, Richmond, Va: Personal communication, 2003.

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

<sup>e</sup>Sun B, California Department of Health Services, Sacramento, Calif: Personal communication, 2003.

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