Public Veterinary Medicine: Public Health

Rabies surveillance in the United States during 1999

John W. Krebs, MS; Charles E. Rupprecht, VMD, PhD; James E. Childs, ScD

Summary: During 1999, 49 states, the District of Columbia, and Puerto Rico reported 7,067 cases of rabies in nonhuman animals to the Centers for Disease Control and Prevention, a decrease of 11.2% from 7,961 cases in nonhuman animals and 1 case in a human being reported in 1998. More than 91% (6,466 cases) were in wild animals, whereas 8.5% (601 cases) were in domestic species (compared with 92.4% in wild animals and 7.6% in domestic species in 1998). No cases of rabies were reported in human beings in 1999. Decreases were evident in all major species groups, with the exception of cattle, sheep/goats, and swine. The relative contributions of the major groups to the total reported were as follows: raccoons (41.0%; 2,872 cases), skunks (29.4%; 2,076), bats (14.0%; 989), foxes (5.4%; 384), cats (3.9%; 278), cattle (1.9%; 135), and dogs (1.6%; 111). Reported cases (6) associated with the epizootic of rabies in raccoons in Ohio declined from the 26 cases reported in 1998. Fifteen of the 19 states where the raccoon variant of the rabies virus is enzootic reported fewer cases of rabies during 1999. Massachusetts and Rhode Island, states with enzootic rabies in raccoons, each reported more rabid skunks than rabid raccoons for the third consecutive year. In Texas, cases associated with the enzootic canine variants of the rabies virus remained low (10 cases), whereas cases associated with the gray fox variant of the virus increased (66). Cases of rabies in skunks decreased by 8.6%, compared with those reported in 1998. Michigan reported the largest percentage increase in rabid skunks (950.0%; 2 cases in 1998 to 21 in 1999). Cases of rabies in horses and mules declined 21%, from 82 cases in 1998 to 65 in 1999. Cases of rabies reported in bats (989) were similar in number to those reported in 1998 (992) and represented almost 14.0% of the total number of rabid animals reported during 1999. Reported cases of rabies in cats (278) and dogs (111) decreased by 1.4% and 1.8%, respectively, whereas cases in cattle (135) increased by 16.4%, compared with those reported in 1998.

In the United States and other developed nations, rabies is primarily a disease that affects and is maintained by wildlife populations (**Fig 1**). During 1999, wild animals accounted for 91.5% (6,466) of all cases reported to the **Centers for Disease Control and Prevention (CDC)**. The relative contributions of those species most frequently reported rabid have changed in recent decades (**Fig 2**) because of fluctuations in epizootics of rabies among animals infected with several distinct variants of the rabies virus.[1]

Vaccination campaigns and control programs implemented during the 1940s and 1950s effectively controlled and all but eliminated the circulation of canine variants of the rabies virus in dogs (*Canis familiaris*) by the 1960s. However, a variant well adapted to dogs emerged in south Texas during the late 1970s and early 1980s. Programs initiated to interrupt transmission of this variant among dogs (*C familiaris*) and coyotes (*C latrans*), as well as a second canine variant found mainly in gray foxes (*Urocyon cinereoargenteus*) in Texas, have to be credited with reducing the spread of rabies virus maintained in these reservoirs. Regulations in Texas and other states that prohibit translocation of certain wild animal species for hunting and other restocking purposes have reduced the likelihood of accidental introductions of these rabies virus variants.[1-3]

Vaccination of domestic livestock and companion animals, oral vaccination programs targeting wildlife, ongoing education programs, and other activities conducted by public health authorities have contributed to reduced transmission of rabies variants to human beings.[4] However, a small but increasing number of cases of rabies in human beings during the previous decade have resulted from infection with variants of the rabies virus that are associated with bats,[5,6] a wildlife group difficult to target for rabies control by conventional methods. An additional challenge to pre-

From the Viral and Rickettsial Zoonoses Branch, Division of Viral and Rickettsial Diseases, National Center for Infectious Diseases, Centers for Disease Control and Prevention, 1600 Clifton Rd NE, Atlanta, GA 30333.

The authors thank the state and territorial health and agriculture departments and laboratories for their contributions of rabies surveillance data; the governments of Canada and Mexico for supplying summaries of rabies surveillance data; Karoyle Colbert, Biometrics Activity, Division of Viral and Rickettsial Diseases, National Center for Infectious Diseases, and Van Munn, Information Resources Management Office, Office of Program Services, Office of the Director, Centers for Disease Control and Prevention, for assistance with graphics; and John P. O'Connor, Office of the Director, Division of Viral and Rickettsial Diseases, National Center for Infectious Diseases, Centers for Disease Control and Prevention, for editing and critical input.

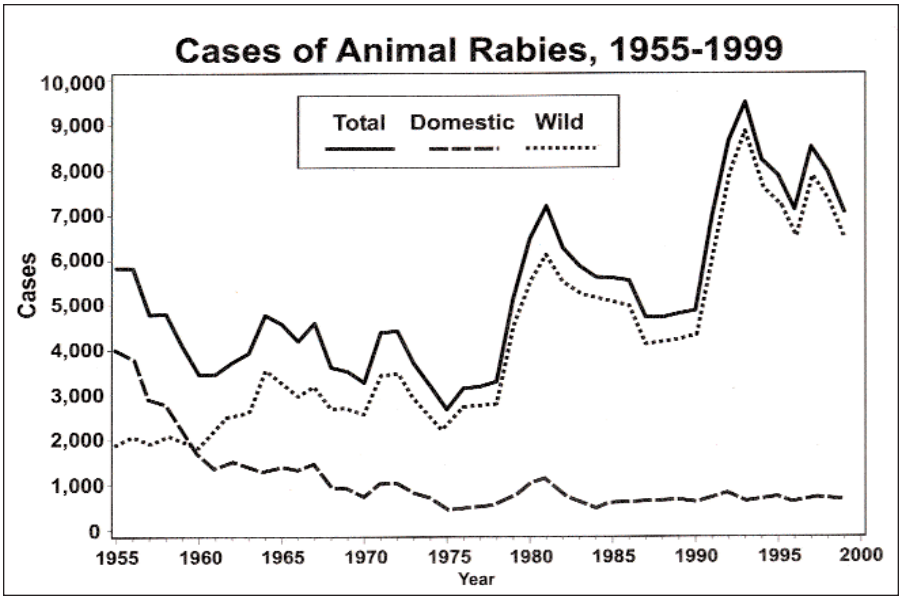

Figure 1—Cases of animal rabies in the United States, by year, 1955 to 1999.

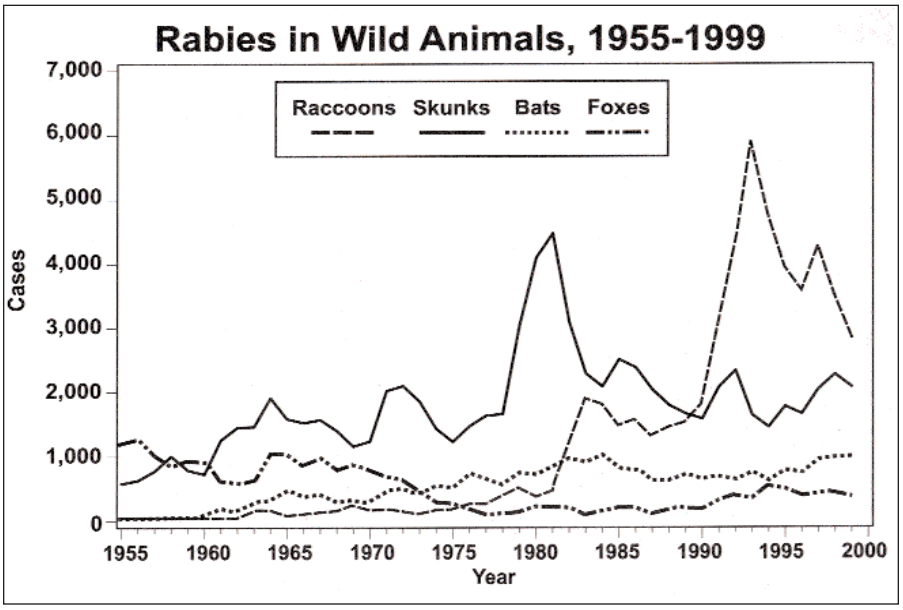

Figure 2—Cases of rabies in wild animals in the United States, by year and species, 1955 to 1999.

vention of rabies from bat variants is that the exposure histories involving a bite are frequently not indicated. During the past decade, 20 of 22 human cases of indigenously acquired rabies were associated, by genetic analysis, with bat variants of the rabies virus. Only 1 of these cases had a definite history of animal bite.[5,6] The most likely route of infection remains transmission by bite during contact with a bat that either was unnoticed or ignored and subsequently forgotten.

Rabies infections of terrestrial animals in most areas of the United States occur in geographically discrete 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 at enzootic levels for decades, even perhaps for centuries.

Compartmentalization of rabies virus by species and geographic area has led to the evolution of distinctive variants. These variants can be identified by reaction with panels of monoclonal antibodies[7] or by patterns of nucleotide substitution identified by genetic analysis.[1,8] The spatial boundaries of enzootic rabies in a reservoir species are dynamic (**Fig 3**). Affected areas usually expand gradually through virus transmission into previously uninfected populations. Natural barriers such as mountain ranges or bodies of water that restrict animal movements or result in low population densities can slow the spread of rabies. Nevertheless, unusual animal dispersal patterns or human-mediated translocation of infected animals have resulted in more rapid and unexpected introduction of rabies into new areas.[1-3,8]

Raccoons (*Procyon lotor*) have been recognized as a reservoir for rabies in the southeastern 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.[9] Although previously identifiable as separate foci, the mid-Atlantic and southeastern foci have merged, and the raccoon variant of the rabies virus is now enzootic in all of the eastern coastal states, as well as Alabama, Pennsylvania, Vermont, West Virginia, and, most recently, parts of Ohio.

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 exists in red and arctic foxes (*Vulpes vulpes* and *Alopex lagopus*, respectively) in Alaska. Rabies spread during the 1950s, affecting foxes across Canada and adjoining areas of the New England states. Rabies persists in foxes in Alaska, whereas reports of rabid foxes have declined in Canada. Foxes infected with this rabies virus variant are only intermittently reported in New England. Two variants of the rabies virus exist in geographically limited populations of gray foxes (*U cinereoargenteus*) in Arizona and Texas. Enzootic rabies

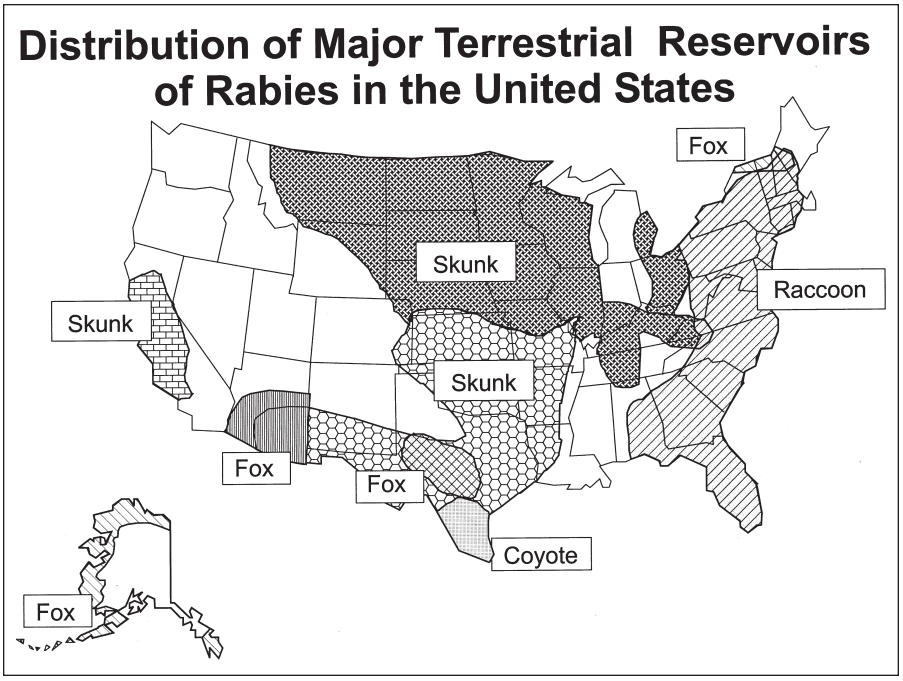

Figure 3—Distribution of major terrestrial reservoirs of rabies in the United States.

in canids in southern Texas is the result of long-standing interaction between unvaccinated domestic dogs and coyotes at the Texas-Mexico border.[10]

Rabies control in wild terrestrial carnivores by population reduction is not desirable nor has it been successful in North America or elsewhere. Programs in Europe and southeastern Canada have instead used modified-live or recombinant virus oral vaccines for free-ranging wildlife reservoir species to control the disease. During the past 2 decades, > 100 million doses of vaccine-laden bait have been distributed over 6 million square kilometers in Europe,[11] with promising results for controlling the disease in red foxes. The use of oral vaccines in Switzerland during the past 20 years resulted in a declaration of rabies-free status in 1998. Similarly, France is progressing toward elimination of the disease among foxes. Substantial decreases 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[12-14] and gray foxes and coyotes in Texas[15] 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.[16]

Overlaying patterns of rabies virus maintenance among terrestrial mammals are multiple, independent reservoirs for rabies virus in several species of insectivorous bats. Rabies virus transmission in bats appears to be primarily intraspecific, and distinct viral 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 range of the bat species themselves. Because bat species known to be reservoirs for rabies are found in all areas of the continental United States, every state except Hawaii is considered enzootic for rabies. Although transmission of rabies from bats to terrestrial mammals occurs, there is no evidence that transmission results in 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.

This report was prepared 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 in reported cases of rabies in various species. Long-term trends in reported cases of rabies in animals in the United States are generated by examining reports starting in 1955. Short-term trends are determined by comparing reported cases from 1999 with those from 1998 and by examining seasonal patterns for selected species.

Summaries of 1999 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 2000 is also included.

Collection of Data

Data collection procedures were similar to those described previously.[2] Between January 1 and December 31, 1999, all 50 states, the District of Columbia, and Puerto Rico reported the number of cases of rabies in animals to the CDC. States submitted data monthly on the number of cases by county of origin and type of animal. States report most terrestrial mammals by using the common names of these animals (usually definable 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. Several states reported data by using the Public Health Laboratory Information System or the Laboratory Information Tracking System.[17,18] All year-end totals were confirmed by telephone verification with state or territorial health department officials. Data from Canada were obtained from Dr. Ron Rogers, Animal Health and Production Division, Canadian Food Inspection Agency, and data from Mexico were obtained from Dr. Oscar Velazquez Monroy, Coordinador de Vigilancia Epidemiologica, Secretaria de Salud, Mexico.

Table 1—Cases of rabies in the United States and Puerto Rico, by state and category, 1999

State/ city	All animals	Domestic	Wild	Domestic animals: Dogs	Cats	Cattle	Horses/ mules	Sheep/ goats	Swine	Other domestic	Wild animals: Skunks	Foxes	Bats	Raccoons	Rodents and lagomorphs*	Other wild†	Human beings	1998	Change‡ %
	7,067	**601**	**6,466**	**111**	**278**	**135**	**65**	**9**	**3**	**0**	**2,076**	**384**	**989**	**2,872**	**45**	**100**	**0**	**7,962**	**−11.24**
AL	124	5	119	2	3							14	23	81		1[n]		102	21.57
AK	13	3	10	3								10						25	−48.00
AZ	81	2	79			2					11	19	48			1[p]		48	68.75
AR	32	6	26	3	2	1					19		7					35	−8.57
CA	351	9	342	5	2			2			183	4	152	1		2[q]		384	−8.59
CO	51	0	51										51					42	21.43
CT	255	10	245		8	2					71	2	21	148	3[a]			455	−43.96
DC	22	1	21	1								1	10	10				10	120.00
DE	58	4	54	1	3						9	3	1	39	2[b]			76	−23.68
FL	186	16	170	2	13		1					32	6	126		6[r]		215	−13.49
GA	247	12	235	4	6	1	1				27	14	18	172		4[s]		309	−20.06
HI	0	0	0															0	—
ID	6	1	5				1						5					17	−64.71
IL	10	0	10										10					17	−41.18
IN	13	0	13										13					12	8.33
IA	159	57	102	9	31	13	3	1			65	1	33	3				152	4.61
KS	107	16	91		6	9	1				82	4	5					100	7.00
KY	35	7	28	2		4	1				21	1	6					32	9.38
LA	6	2	4		1		1				2		2					3	100.00
ME	208	8	200		7		1				72	4	7	116	1[c]			248	−16.13
MD	394	22	372		19	1	2				26	22	4	311	8[d]	1[t]		439	−10.25
MA	226	4	222	1	3						114	5	21	78	4[e]			498	−54.62
MI	92	3	89				3				21		67			1[u]		35	162.86
MN	120	36	84	8	11	15	2				72		10			2[v]		119	0.84
MS	2	0	2										2					2	0.00
MO	31	4	27		2	1	1				11		15	1				41	−24.39
MT	64	6	58	3	1				2		44		14					66	−3.03
NE	4	0	4								1		3					7	−42.86
NV	12	0	12										12					6	100.00
NH	47	4	43		3	1					14	10	1	18				83	−43.37
NJ	197	16	181		15	1					37	2	16	122	3[f]	1[w]		252	−21.83
NM	9	2	7		2								7					6	50.00
NY	919	46	873		31	8	7				187	44	117	512	10[g]	3[x]		1,095	−16.07
NYC	10	0	10										1	8		1[y]		1	900.00
NC	442	23	419	5	13	1	2	2			50	35	23	304	2[h]	5[z]		560	−21.07
ND	147	43	104	6	9	21	7				100	1		2		1[aa]		155	−5.16
OH	36	0	36										30	5	1[i]			59	−38.98
OK	94	23	71	3	6	9	5				67		3			1[bb]		108	−12.96
OR	4	1	3			1							3					5	−20.00
PA	357	28	329		22	3	2	1			91	22	17	194	5[j]			380	−6.05
PR	75	16	59	11	1		3		1							59[cc]		51	47.06
RI	101	0	101								60	3	3	35				107	−5.61
SC	145	7	138	4	3						14	22	9	89		4[dd]		154	−5.84
SD	180	52	128	13	10	22	7				120	1	6			1[ee]		166	8.43
TN	83	4	79	4							67	1	11					142	−41.55
TX	400	54	346	13	21	8	9	3			192	56	90	4		4[ff]		303	32.01
UT	8	0	8										8					27	−70.37
VT	92	1	91		1						24	1	2	64				72	27.78
VA	581	35	546	4	23	7	1				127	42	17	354	4[k]	2[gg]		550	5.64
WA	25	0	25										25					27	−7.41
WV	115	2	113	1		1					19	8	9	75	2[m]			77	49.35
WI	21	4	17	3			1				13		4					19	10.53
WY	70	6	64			3	3				43		21					68	2.94
% 1999§	100.00	8.50	91.50	1.57	3.93	1.91	0.92	0.13	0.04	0.00	29.38	5.43	13.99	40.64	0.64	1.42	0.00		
Total 1998‖	7,962	603	7,358	113	282	116	82	8	1	1	2,272	435	992	3,502	68	89	1		
% change‡	−11.24	−0.33	−12.12	−1.77	−1.42	16.38	−20.73	12.50	200.00	−100.00	−8.63	−11.72	−0.30	−17.99	−33.82	12.36	−100.00		

*Rodents and lagomorphs include: [a]3 groundhogs; [b]1 groundhog, 1 rabbit; [c]1 groundhog; [d]1 beaver, 7 groundhogs; [e]4 groundhogs; [f]3 groundhogs; [g]10 groundhogs; [h]2 groundhogs; [i]1 chipmunk; [j]1 beaver, 4 groundhogs; [k]1 beaver, 3 groundhogs; [m]2 groundhogs. †Other wild includes: [n]1 bobcat; [p]1 coyote; [q]1 opossum, 1 wolf-dog hybrid; [r]3 bobcats, 3 otters; [s]4 bobcats; [t]1 weasel; [u]1 wapiti; [v]1 badger, 1 opossum; [w]1 deer; [x]1 bear, 1 bobcat, 1 deer; [y]1 coyote; [z]3 bobcats, 1 coyote, 1 deer; [aa]1 bison; [bb]1 coyote; [cc]59 mongooses; [dd]4 bobcats; [ee]1 badger; [ff]2 bobcats, 2 coyotes; [gg]2 bobcats. ‡Percentage change from 1998. §Percentage of all rabid animals in 1999. ‖1998 total by species.

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 of mice and nucleic acid detection via **reverse transcriptase**

(RT)-polymerase chain reaction assays were used to confirm some cases.

Rabies in Wild Animals

Wild animals accounted for 91.5% of the 7,067 reported cases of rabies in 1999 (Fig 1). The 6,466 cases reported among wildlife in 1999 represented a 12.1% decrease from the 7,358 cases reported in 1998 (**Table 1**). Raccoons continued to be the most frequently reported rabid wildlife species (40.6% of all animal cases during 1999), followed by skunks (29.4%), bats (14.0%), foxes (5.4%), and other wild animals, including rodents and lagomorphs (2.1%). Reported cases in raccoons, foxes, skunks, and bats decreased 18.0, 11.7, 8.6, and 0.3% from 1998 totals, respectively.

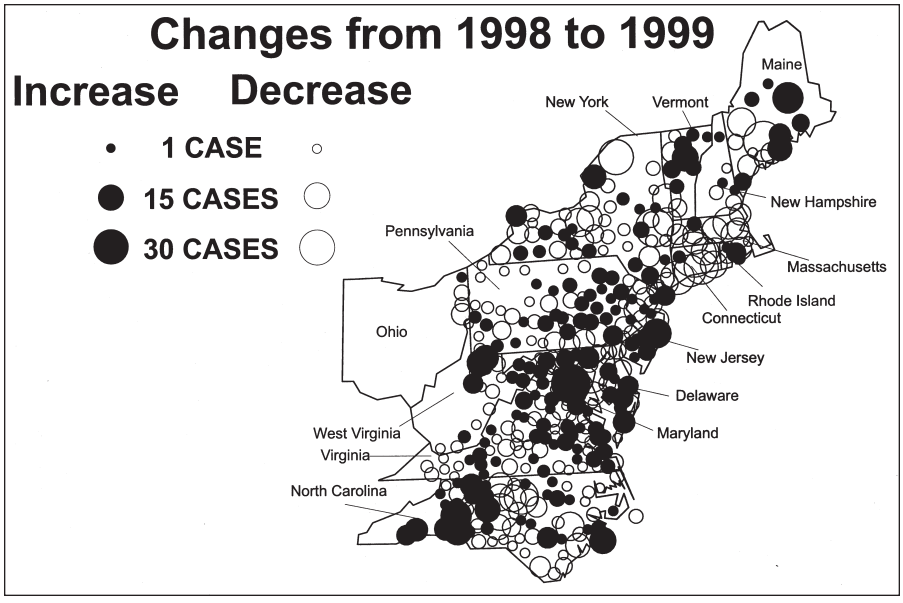

Figure 4—Changes in cases of rabies in raccoons in the mid-Atlantic and northeastern states, 1998 to 1999. Dot size is proportional to the number of cases in the county.

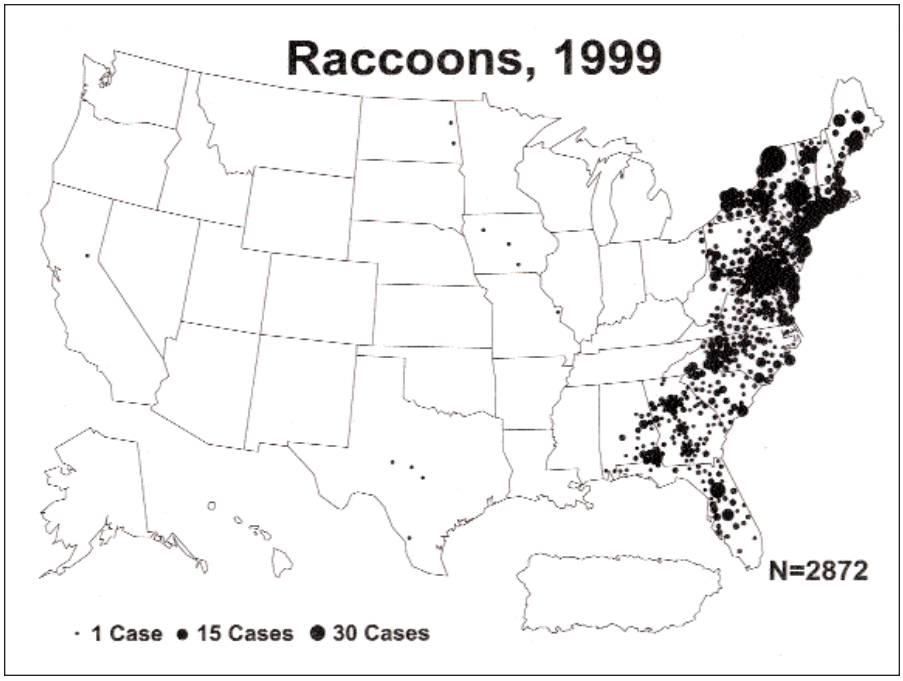

Figure 5—Reported cases of rabies in raccoons, by county, 1999.

Raccoons—The 2,872 cases of rabies in raccoons (*P lotor*) in 1999 marked the third consecutive year of decreased reports in this species (**Fig 2** and **4**). Fewer rabid raccoons were reported in 1999 by 14 of the 19 eastern states in which raccoon rabies is enzootic, including Connecticut (52.6% decrease; 312 cases in 1998 to 148 in 1999), Delaware (11.4%; 44 to 39), Florida (17.6%; 153 to 126), Georgia (17.7%; 209 to 172), Maine (18.9%; 143 to 116), Maryland (10.1%; 346 to 311), Massachusetts (58.3%; 187 to 78), New Hampshire (21.7%; 23 to 18), New Jersey (12.2%; 139 to 122), New York (24.5%; 689 to 520), North Carolina (21.0%; 385 to 304), Ohio (75%; 20 to 5), Pennsylvania (13.4%; 224 to 194), and South Carolina (6.3%; 95 to 89; **Fig 4** and **5**, Table 1).[2,8,9,12,19] Five states with enzootic raccoon rabies reported increases in rabid raccoons: Alabama (17.4% increase), Rhode Island (20.7%), Vermont (39.1%), Virginia (8.6%), and West Virginia (50.0%).

The District of Columbia and 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, reported 72.7% (2,089 cases) of the total cases of rabies in raccoons in 1999, whereas the southeastern states of Alabama, Florida, Georgia, North Carolina, and South Carolina reported 26.9% (772 cases) of the total cases in raccoons.

Cases of rabies in raccoons reported by California (1 case), Iowa (3), Missouri (1), North Dakota (2), and Texas (4) were most likely the result of spillover infection with variants of the rabies virus other than that associated with raccoons (usually the north central skunk variant, except in California, where the California skunk variant of the rabies virus is involved, and in Texas, where spillover could involve either the gray fox variant or

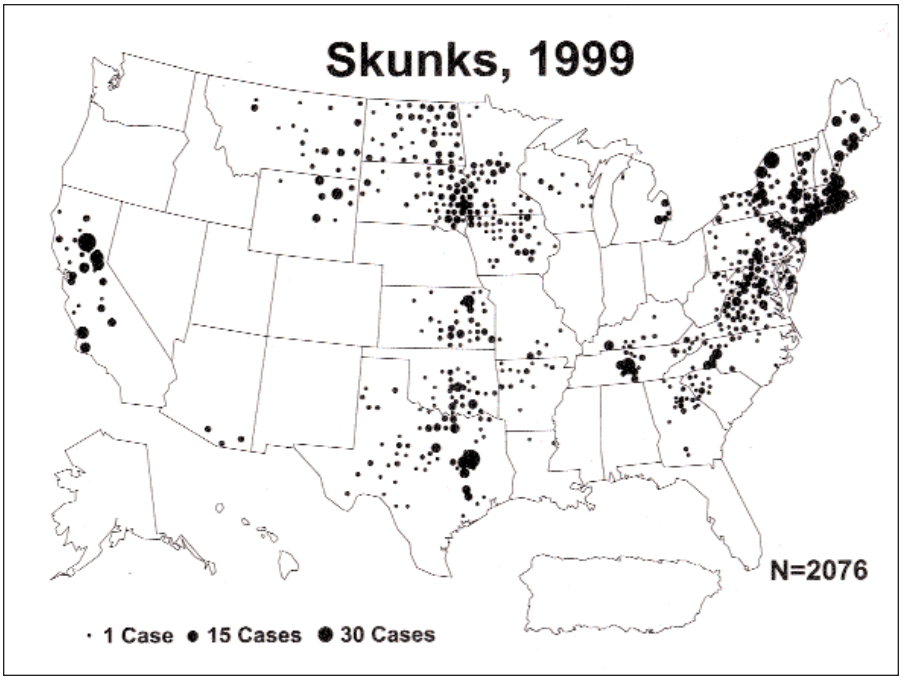

Figure 6—Reported cases of rabies in skunks, by county, 1999.

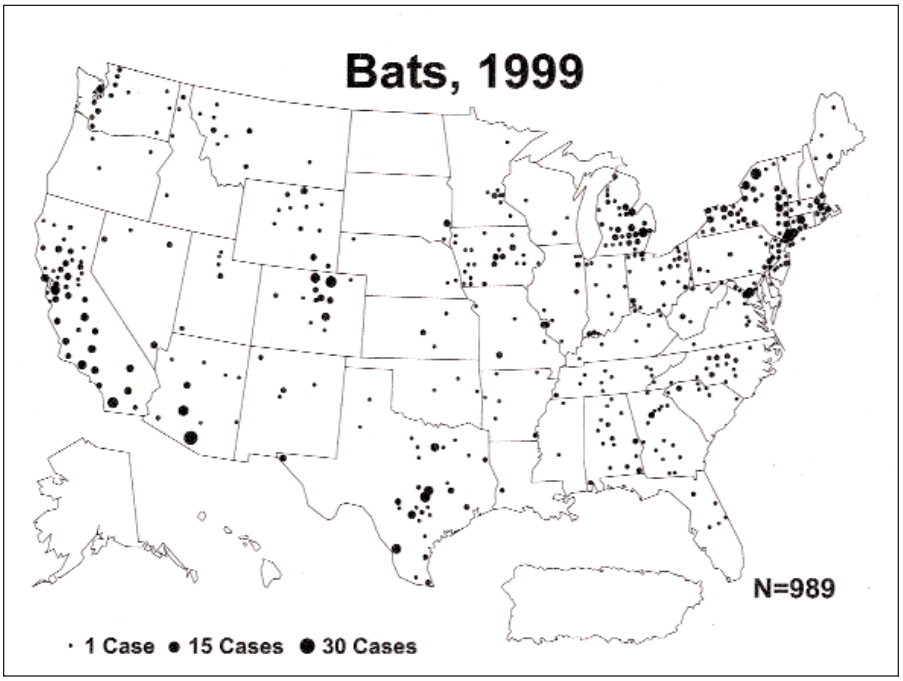

Figure 7—Reported cases of rabies in bats, by county, 1999.

the south central skunk variant). In 1999, with the exception of Ohio, states west of the Ohio River in the North and west of the Appalachian Mountains in the South did not report any cases of rabies believed to be associated with the raccoon variant of the rabies virus.

Skunks—The 2,076 cases of rabies in skunks (mainly *M mephitis*) were reported from 35 states in 1999 (**Fig 6**). Twenty-six states reported a decrease in rabid skunks, compared with reported cases in 1998, with 7 of these states reporting no cases of rabies in skunks during 1999. Sixteen states reported an increase in rabid skunks; 2 of these states did not report any cases of rabies in skunks in 1998. Only Massachusetts (54% [248 cases to 114 cases]) reported a decrease of > 50%, compared with the number of cases reported in 1998. Three states reported increases of > 100%, compared with 1998 totals, although absolute numbers were small (Arizona, 266.7% [3 cases to 11]; Michigan, 950.0% [2 to 21]; and West Virginia, 171.4% [7 to 19]). States with enzootic or epizootic rabies in raccoons reported 45.6% (942/2,067) of the cases of rabies in skunks, the majority of which were presumably the result of spillover transmission of virus from raccoons. Massachusetts and Rhode Island, however, each reported more rabid skunks than rabid raccoons for the third consecutive year.

Bats—Rabies in bats accounted for 14.0% of all cases of rabies in animals reported in 1999. The 989 reported cases represented a 0.3% decrease from those reported in 1998. Rabies in bats is widely distributed throughout the United States, with cases reported from 47 of the 48 contiguous states (**Fig 7**). During 1999, California reported the largest number of cases (152), followed by New York (118), and Texas (90). Seven states (Colorado, Illinois, Indiana, Mississippi, Nevada, Utah, and Washington) 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 reported that tested positive for rabies virus, 61.6% (609/989) were identified beyond the taxonomic level of order (8 to genus, 601 to species), 49.8% (299/601) were *Eptesicus fuscus*, the big brown bat; 25.5% (153/601) were *Tadarida brasiliensis*, the Brazilian (Mexican) free-tailed bat; 5.0% (30/601) were *Lasiurus cinereus*, the hoary bat; 4.0% (24/601) were *Myotis lucifugus*, the little brown bat; 3.8% (23/601) were *Pipistrellus hesperus*, the

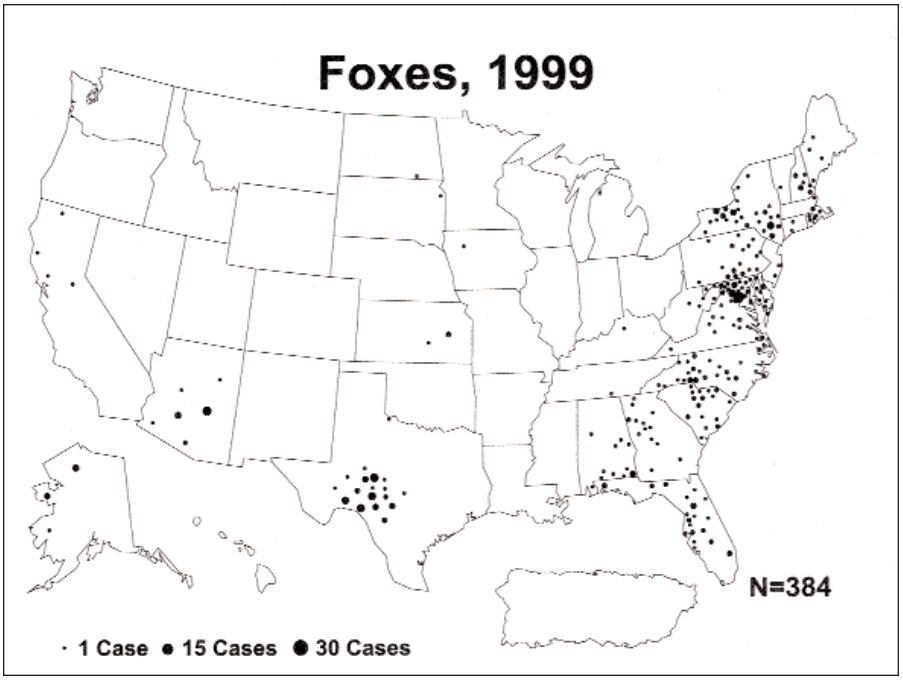

Figure 8—Reported cases of rabies in foxes, by county, 1999.

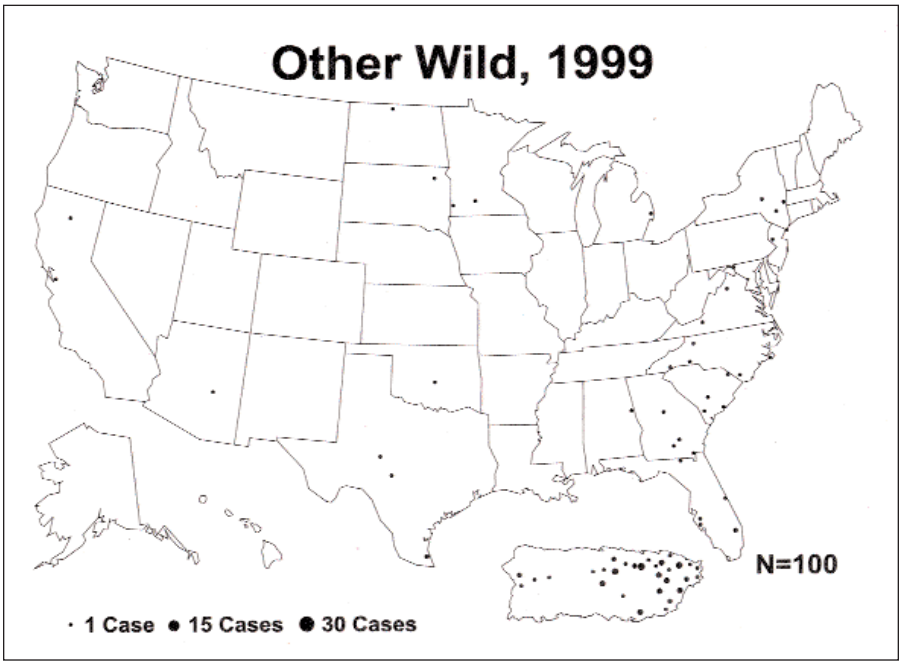

Figure 9—Reported cases of rabies in other wild animals, by county and municipio (Puerto Rico), 1999.

western pipistrelle; 2.3% (14/601) were *Lasiurus borealis*, the red bat; 2.0% (12/601) were *Lasionycteris noctivagans*, the silver-haired bat; and 2.0% (12/601) were *Myotis californicus*, the California bat. Unspeciated bats of the genus *Myotis* (1.3% [8/601]) and 9 other species (contributing < 7% [42/601] to the total, with no individual species in this latter group contributing > 1.2%) 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 *V vulpes*) accounted for 5.4% of all cases of rabies in animals reported in 1999. The majority of cases of rabies in foxes were reported by states affected by the raccoon variant of the rabies virus **(Fig 8)**. Georgia (14 cases), Maine (4), and New Hampshire (10) reported decreases of 16, 22, and 19 cases, respectively, compared with cases reported in 1998. Arizona (19 cases), Florida (32), and Texas (56) reported increases of 19, 11, and 35 cases, respectively. With the possible exception of Maine, New Hampshire, New York, and Vermont, most cases of rabies in foxes reported by eastern states were probably caused by the raccoon variant of the rabies virus. Rabies in gray foxes in Arizona and Texas is usually (antigen typing and genetic analysis) the result of infection with the gray fox variant epizootic in that species in Arizona and west central Texas, respectively. Arizona (19 cases), Iowa (1), North Dakota (1), and the District of Columbia (1) reported rabies in foxes in 1999, but did not report any cases of rabies in foxes in 1998.

Other wild animals—Puerto Rico reported 59 cases of rabies in mongooses (*Herpestes auropunctatus*), a 68.6% increase from the 35 cases reported in 1998 (Fig 9). Other wildlife in which rabies was reported included 40 groundhogs (*Marmota monax*), 20 bobcats (*Felis rufus*), 6 coyotes (*C latrans*), 3 beavers (*Castor canadensis*), 3 deer (*Odocoileus virginianus*), 3 otters (*Lutra canadensis*), 2 badgers (*Taxadea taxus*), 2 opossums (*Didelphis virginiana*), 1 chipmunk (*Tamias striatus*), 1 bear (*Ursus americanus*), 1 bison (*Bison bison*), 1 wapiti (elk; *Cervus elephas*), 1 rabbit (*Oryctolagus cuniculus*), 1 weasel (*Mustela* sp), and 1 wolf-dog hybrid (*Canis lupus* × *C familiaris*). All cases of rabies in rodents and lagomorphs (primarily groundhogs, 40/45 cases) were reported by states in which rabies is enzootic in raccoons.[20] Two of the 6 cases of rabies in coyotes were associated with enzootic transmission of the dog/coyote variant of the rabies virus in regions of southern Texas **(Fig 9)**.

Rabies in Domestic Animals

Domestic species accounted for 8.5% of all rabid animals reported in the United States in 1999. The number of domestic animals reported rabid in 1999 (601) was 2 less than cases reported in 1998 (**Fig 10**). Cases of rabies reported in cats and dogs decreased 1.4 and 1.8%, respectively, compared with totals reported in 1998, whereas reports of rabies in cattle increased 16.4%. Reported cases of rabies in cats were more than twice those reported in dogs or cattle. Iowa reported the largest number of rabid domestic animals (57), followed by Texas (54), South Dakota (52), and New York (46).

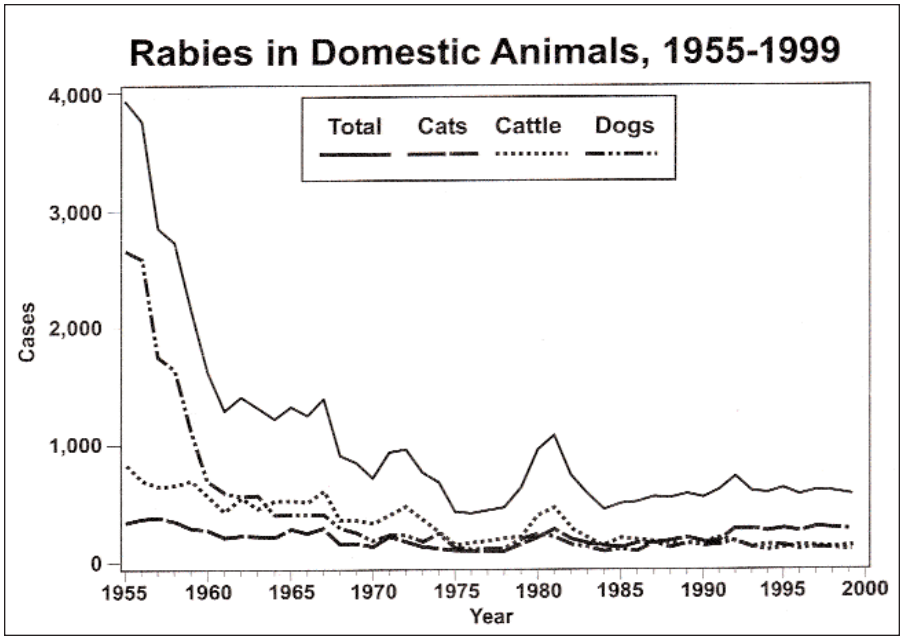

Figure 10—Cases of rabies in domestic animals in the United States, by year, 1955 to 1999.

Cats—The majority of the 278 cases of rabies in cats were reported from states where the raccoon 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 from rabid foxes in Texas. Ten states reported > 10 cases of rabies in cats (Iowa, 31 cases; New York, 31; Virginia, 23; Pennsylvania, 22; Texas, 21; Maryland, 19; New Jersey, 15; Florida, 13; North Carolina, 13; and Minnesota, 11). Twenty-one states and the District of Columbia did not report any rabid cats.

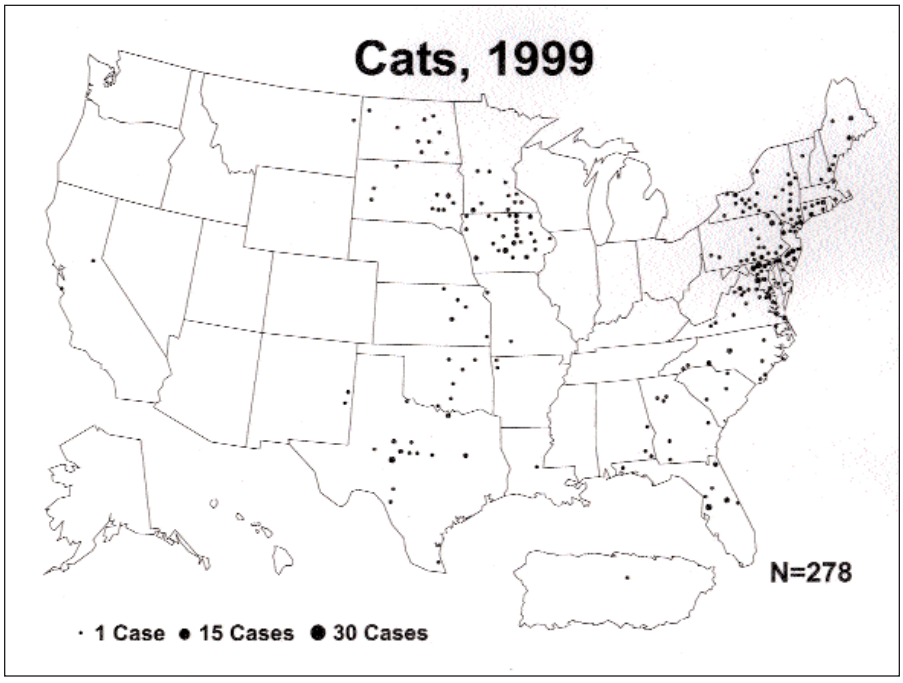

Figure 11—Reported cases of rabies in cats, by county and municipio (Puerto Rico), 1999.

Dogs—South Dakota and Texas each reported 13 cases of rabies in dogs, the highest number reported by any state during 1999. Two of the cases in dogs reported by Texas occurred within the west central area, where rabies in gray foxes is enzootic, and 5 cases were associated with the enzootic transmission of rabies virus that occurs in coyotes and dogs in south Texas (**Fig 12**). Only Puerto Rico (11 cases), Iowa (9), Minnesota (8), and North Dakota (6) reported > 5 cases of rabies in dogs during 1999. Twenty-seven states did not report any rabid dogs.

Other domestic animals—Cases of rabies in cattle increased from 116 in 1998 to 135 in 1999 (**Fig 13**) and mirrored the cases of rabid skunks in the central and midwestern states (Fig 6 and 13) and those of rabid raccoons in the mid-Atlantic and northeastern regions (Fig 5 and 13). South Dakota (22 cases), North Dakota (21), Minnesota (15), and Iowa (13) reported the largest numbers of rabid cattle. No other state reported > 9 cases of rabies in cattle. The 65 cases of rabies reported in horses, donkeys, and mules in 1999 represented a 20.7% decrease, compared with the 82 cases reported in 1998. Other reported cases of rabies in domestic animals included 7 goats, 2 sheep, and 3 swine.

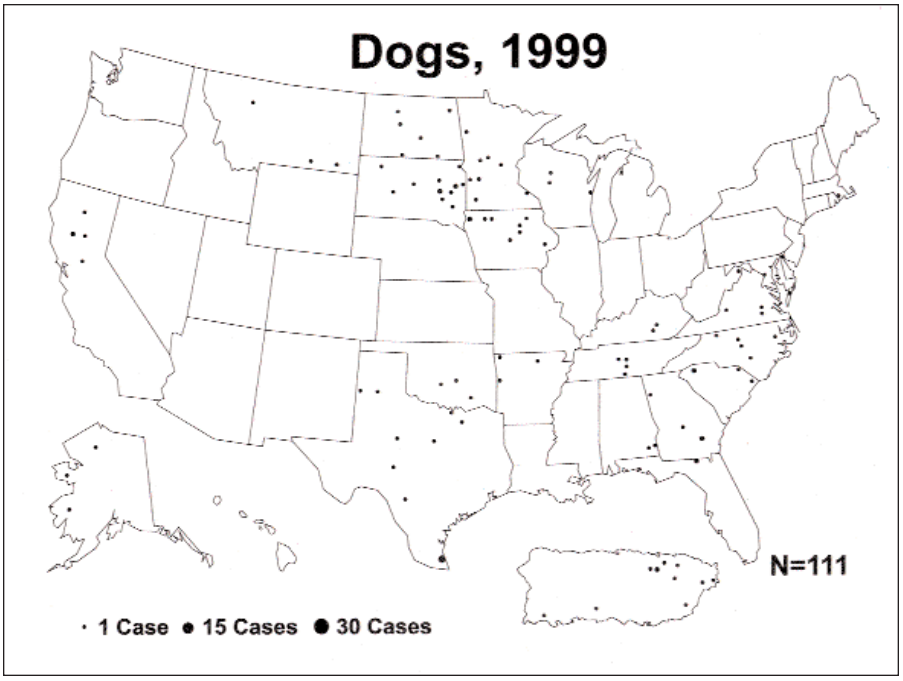

Figure 12—Reported cases of rabies in dogs, by county and municipio (Puerto Rico), 1999.

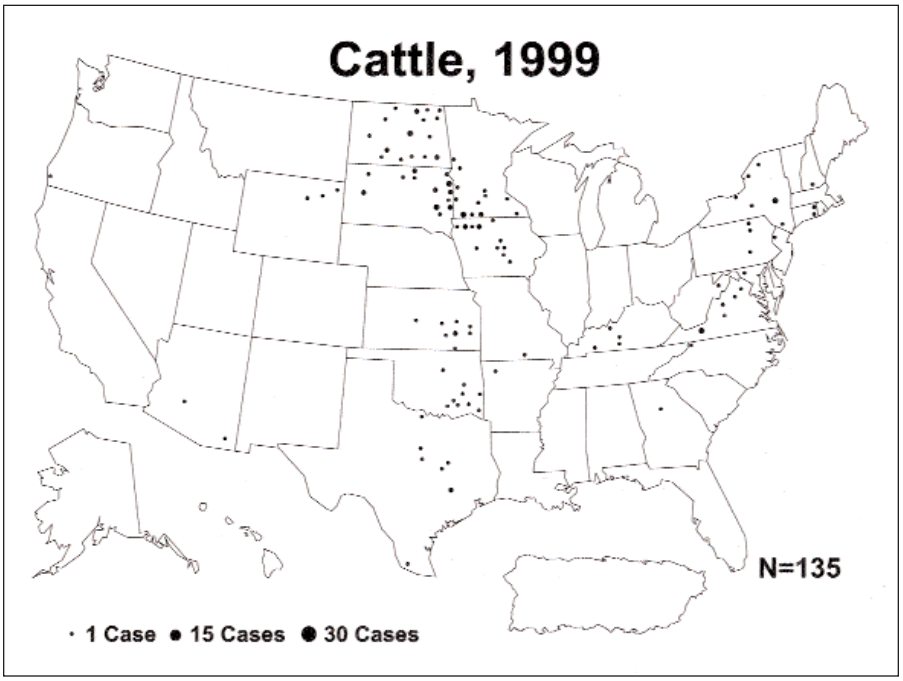

Figure 13—Reported cases of rabies in cattle, by county, 1999.

Seasonal Trends

The frequency of reported cases of rabies in raccoons peaked in March and April, declined through the summer, and increased again in September (**Fig 14**). The frequency of reporting for rabid skunks was bimodal, with a peak in March and a second broad peak from September to November. Reports of rabid bats showed a strong summer and fall peak. Monthly reports of rabid foxes were low, with the highest numbers reported during July.

Rabies in cats was highest during the summer. Reporting of rabies in dogs and cattle occurred in every month, but showed no clear pattern (**Fig 15**).

Rabies in Human Beings

No cases of rabies in human beings were reported during 1999.

Rabies in Canada and Mexico

Canada reported 500 laboratory-confirmed cases of rabies in domestic and wild animals in 1999. This represented a 34.4% increase over the 372 cases reported in 1998. For the second consecutive year, most of this increase was attributable to increases in reported cases of rabies in skunks in the provinces of Manitoba and Saskatchewan. Reported cases in skunks increased by 52.4% (355 in 1999, compared with 233 cases in 1998) and accounted for 71% (355/500) of all rabid animals reported in 1999. Reported cases of rabies in bats decreased 25% (42 cases in 1999, compared with 56 in 1998) and accounted for 8.4% (42/500) of all reported cases of rabies. Other species that contributed substantially to the 1999 total included cattle (7.8%), foxes (4.8%), raccoons (2.6%), and dogs (2.2%). Canada did not report any cases of rabies in human beings for 1999.

Mexico reported 486 laboratory-confirmed cases of rabies in domestic and wild animals during 1999. This total represented a 4.7% decrease, compared with the 463 cases reported in 1998. Dogs accounted for 65.2% (317/486) of reported cases of rabies, a decrease of 5.4%, compared with cases reported in 1998 (335). The other reported rabid animals included 108 cattle, 18 cats, 9 bats, 8 equids, 6 skunks, 5 swine, 4 goats, 4 sheep, 1 coyote, 1 fox, and 5 unidentified species. Nine cases of rabies were reported in human beings, a 40.0% decrease from 1998 (15 cases). Source animals implicated in the exposure of the human beings were reported as follows: bats (4 cases), dogs (3), and skunk (1). Exposure history was unknown in 1 case.

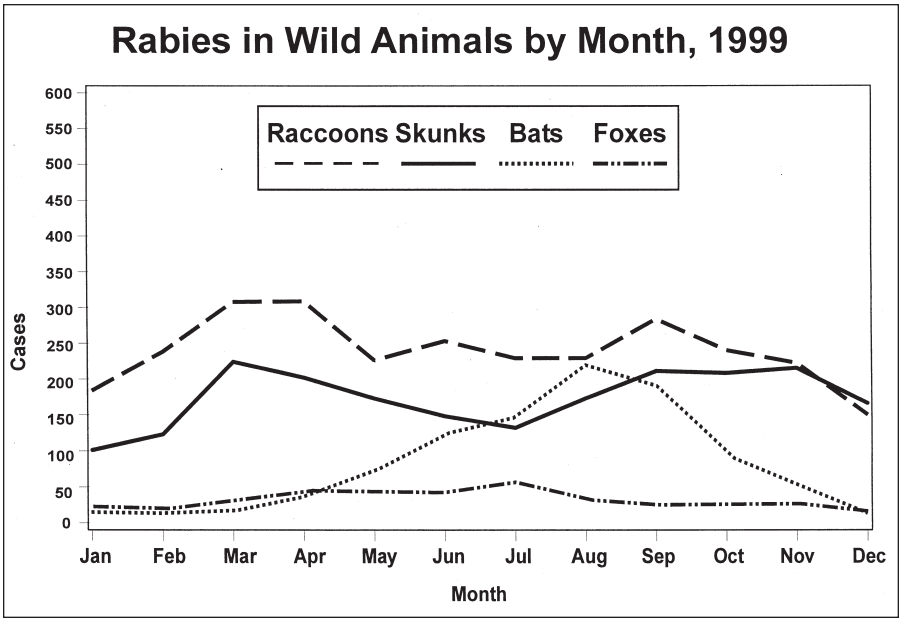

Figure 14—Cases of rabies in wild animals in the United States, by month, 1999.

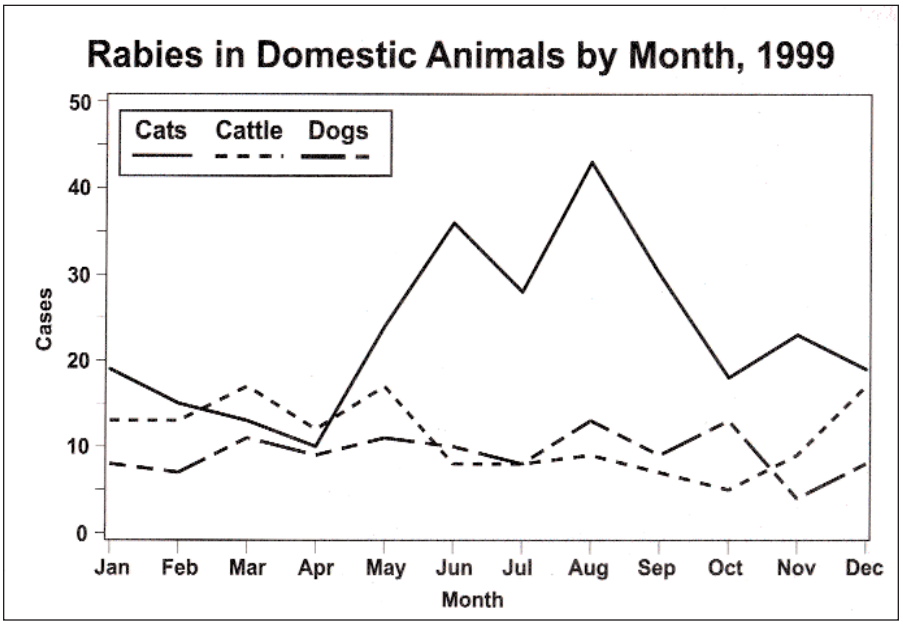

Figure 15—Cases of rabies in domestic animals in the United States, by month, 1999.

Discussion

Reported cases of rabies provide only a rough 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, territorial, and the District of Columbia 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, thus, go untested and undetected.[21]

The percentage contribution of reported cases of rabies in raccoons has continued to decline from a high of > 62% in 1993. Raccoons, nonetheless, continued to account for the highest percentage (40.6%) of rabies cases reported among animals in the United States in 1999 (Fig 2). Enzootic transmission of rabies among raccoons was evident in 19 states and the District of Columbia in 1999. States in the affected area reported 99.6% (2,861/2,872) of all cases of rabies in raccoons and accounted for 67.4% (4,762/7,067) of the total cases of rabies reported in the United States during 1999. Periodic increases in reported cases of rabies in states where the disease is enzootic among raccoons can occur when populations of raccoons, decimated by a previous epizootic, again reach densities sufficient to support transmission of rabies.

Interventions to vaccinate wild raccoons to prevent or slow the dissemination of rabies continue in a number of states. The efficacy of these programs, using the V-RG virus vaccine distributed within baits, remains under assessment in Florida (Pinellas County), eastern Massachusetts (Cape Cod),[1] southern New Jersey (Cape May),[13] New York, and Vermont.[22] In Ohio, 1.5 million additional doses of the V-RG vaccine were distributed over > 2,500 square miles in 6 counties during the spring, summer, and fall of 1999 in an effort to halt the further western spread of rabies in raccoons. Additional states are expected to use the V-RG virus vaccine for raccoon rabies control in the future. Concerns regarding vaccine safety, efficacy, ecologic impact, and physical bait variables addressed during earlier trials remain.[23-25] The V-RG virus 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.

Reductions in reported cases of rabies in skunks in 1999 were apparent in western states where skunks are the predominant reservoir species (218 fewer cases; 951 in 1999, compared with 1,169 in 1998) and in the East where states are affected by the epizootic of rabies in raccoons (161 fewer cases; 942 in 1999, compared

Table 2—Cases of rabies in human beings in the United States, by circumstances of exposure and rabies virus variant, 1990 to 2000*

Date of death	State of residence	Exposure history†	Rabies virus variant‡
5 Jun 90	TX	Bat bite—TX	Bat, Tb
20 Aug 91	TX	Unknown§	Dog/coyote
25 Aug 91	AR	Unknown§	Bat, Ln/Ps
8 Oct 91	GA	Unknown§	Bat, Ln/Ps
8 May 92	CA	Dog bite—India	Dog, India
11 Jul 93	NY	Unknown§	Bat, Ln/Ps
9 Nov 93	TX	Unknown	Bat, Ln/Ps
21 Nov 93	CA	Dog bite—Mexico	Dog, Mexico
18 Jan 94	CA	Unknown	Bat, Ln/Ps
21 Jun 94	FL	Unknown—Haiti	Dog, Haiti
11 Oct 94	AL	Unknown§	Bat, Tb
15 Oct 94	WV	Unknown§	Bat, Ln/Ps
23 Nov 94	TN	Unknown§	Bat, Ln/Ps
27 Nov 94	TX	Unknown	Dog/coyote
15 Mar 95	WA	Unknown§	Bat, Msp
21 Sep 95	CA	Unknown§	Bat, Tb
23 Oct 95	CT	Unknown	Bat, Ln/Ps
9 Nov 95	CA	Unknown§	Bat, Ln/Ps
8 Feb 96	FL	Dog bite—Mexico	Dog, Mexico
20 Aug 96	NH	Dog bite—Nepal	Dog, SE Asia
15 Nov 96	KY	Unknown	Bat, Ln/Ps
19 Dec 96	MT	Unknown	Bat, Ln/Ps
5 Jan 97	MT	Unknown§	Bat, Ln/Ps
18 Jan 97	WA	Unknown§	Bat, Ef
17 Oct 97	TX	Unknown§	Bat, Ln/Ps
23 Oct 97	NJ	Unknown§	Bat, Ln/Ps
31 Dec 98	VA	Unknown	Bat, Ln/Ps
20 Sep 00	CA	Unknown	Bat, Tb
9 Oct 00	NY	Dog bite—Ghana	Dog, Africa
13 Oct 00	GA	Unknown§	Unknown
25 Oct 00	MN	Bat bite—MN	Bat, Ln/Ps

*All laboratory-confirmed cases of rabies in human beings who developed the disease in the United States through October 2000. †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 are identified with the names of the reservoir animal (dog or dog/coyote, 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 name(s) of the species of bat(s) in which they have been found to be circulating. In some instances, the known or presumed geographic location of human beings when they were infected may rule out one of the species indicated for the variant known as the silver-haired/eastern pipistrelle variant (Ln/Ps). Because information regarding the location of the exposure and the identity of the exposing animal is almost always retrospective, and much information is frequently unavailable, the location of the exposure and the identity of the animal responsible for the infection are often limited to deduction. §In some instances for which the exposure history is unknown, there may have been known or inferred contact that, especially for bats, could have involved an imperceptible bite.

Ln/Ps = *Lasionycteris noctivagans* or *Pipstrellus subflavus*, the silver-haired bat or the eastern pipistrelle. Msp = *Myotis*, species unknown. Tb = *Tadarida brasiliensis*, the Brazilian (Mexican) free-tailed bat. Ef = *Eptesicus fuscus*, the big brown bat.

with 1,103 in 1998). Large percentage increases (> 100%) were seen in only 3 states (Arizona, Michigan, and West Virginia), where numbers were small. In Michigan, 2 skunks testing positive for rabies as a result of deviation from that state's routine surveillance testing algorithm increased public awareness of rabies infection in skunks and caused further deviation from the algorithm. Increased submissions of skunks for rabies testing resulted in 17 additional skunks testing positive for rabies.[a]

Rabid skunks again outnumbered reported rabid raccoons in Massachusetts (114 cases in skunks, compared with 78 cases in raccoons) and Rhode Island (60 cases in skunks, compared with 35 in raccoons) for the third consecutive year. This trend heightens concern that skunks may be involved in enzootic transmission of the raccoon variant of the rabies virus. Verification of this concern remains elusive, because reported cases of rabies in skunks and raccoons overlap temporally and geographically.

Although rabies in foxes decreased in most states, noteworthy increases of 19 and 35 cases in Arizona and Texas, respectively, resulted from infections with unique regional terrestrial variants of the rabies virus associated with gray foxes in each of those states.

The occurrence of rabies in various species of bats fluctuates by geographic region. The continued association of bat variants of the rabies virus with human rabies infections during recent years has brought increased publicity, and changes in public health recommendations regarding possible rabies exposures that involve bats have played an important role.

Rabies among rodents and lagomorphs reflects spillover infection, predominantly from regional terrestrial reservoir species. Reported cases in this group occur primarily in groundhogs in areas affected by the raccoon variant of the rabies virus. Ohio reported a case of rabies in a chipmunk (*Tamias striatus*) in 1999. There has been no documentation of rabies transmission from a rodent to a human being. Large species of rodents and lagomorphs, or those kept in cages, may become infected and survive long enough to pose a risk to other species.[20]

Additional distributions of oral rabies vaccine (V-RG; 2.7 million baits delivered over > 33,000 square miles) were completed during 1999 in Texas to interrupt the transmission of rabies in gray foxes, dogs, and coyotes.[15,26,27] Translocations of animals infected with canid variants of the rabies virus found in Texas have been documented.[2,3] 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.

The number of reported cases of rabies among domestic animals remained essentially unchanged from 1998. Numbers of rabid cats decreased slightly (1.4% from 1998), most likely because of declines in numbers of rabid raccoons.

Reports of rabid dogs remain uncommon in the western United States. Ever lower numbers of reported cases of rabies in dogs attest to the effectiveness of public health programs aimed at preventing rabies in domestic animals through spillover from infected wild animals. Vaccination remains the crucial element in this effort.

Vaccination of pets provides a barrier to infection of human beings via their pet animals, and 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.[28-30] 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.[31]

Cases of rabies in equids declined 20.7% from those reported in 1998. Thirty-five of the 65 cases of rabies in horses and mules in 1999 were reported by 5 states (New York, North Dakota, Oklahoma, South Dakota, and Texas).

Cases of rabies diagnosed in human beings in the United States from 1990 to 1999 remains at 27. Twenty-two of these individuals were infected with variants of the rabies virus indigenous to the United States. Monoclonal antibody analysis and genetic sequencing indicated that 20 of these 22 persons were infected with variants of the rabies virus associated with bats (**Table 2**).[5,6] The prevention of infection of human beings with rabies virus from bats, although a rare occurrence, remains a considerable public health concern.[32]

Rabies in bats is epidemiologically distinct from terrestrial rabies maintained by carnivores. Understanding of the circulation of rabies variants in bat species remains less well developed, compared with knowledge of circulation in carnivores. Successful control of terrestrial rabies in the United States through the use of oral vaccines, as has been accomplished in Europe[11,33] and southeastern Canada,[34] will have no effect on enzootic rabies in bats and the associated risk of human disease.

2000 Rabies Update

During the first 9 months of 2000, no cases of rabies were reported that were attributable to infection with the raccoon variant of the rabies virus in Ohio, compared with 5 cases associated with this variant that were reported during 1999. Ohio rabies control programs distribute V-RG baits on the basis of data gathered via active surveillance programs implemented in affected areas, as well as a statewide passive surveillance system. An additional 1.1 million doses of V-RG vaccine were distributed over a total of > 2,500 square miles in 6 counties during 2000.[b]

The front of the epizootic of rabies in raccoons, which borders Ohio in the north and stretches across West Virginia, reaching south almost to the borders of the states of Kentucky and Tennessee, has again advanced westward in those areas south of Ohio. Thus, rabies in raccoons may soon be detected in Kentucky and Tennessee. The risk for introduction of the raccoon variant of the rabies virus into other midwestern states must be considered.

In Texas, an additional 1.85 million doses of the V-RG vaccine were distributed over 39 counties covering > 25,000 square miles during 2000. During the first 9 months of 2000, no cases of rabies attributable to the dog-coyote variant of the rabies virus have been reported in Texas. During this same period, 54 cases of rabies attributable to the variant of the rabies virus associated with gray foxes were reported in foxes and other species; however, no animals infected with this variant were reported outside of the original oral rabies vaccination program treatment area. Since the programs were initiated in 1995, > 13 million doses of the V-RG vaccine have been distributed over > 196,000 square miles.[c] Expansion of the area in Canada affected by the epizootic of rabies in raccoons beyond southern Ontario, where the first cases of rabies associated with the raccoon variant of the rabies virus were reported during July 1999, has occurred. Most recently, a skunk infected with the raccoon variant of the rabies virus was reported in the province of New Brunswick. This may represent an independent second zone of extension of the rabies epizootic in raccoons into Canada originating from the state of Maine.

Addendum

Five cases of rabies in human beings have been reported in the United States and Canada during September and October 2000. On September 20, 2000, a 49-year-old man from Amador County, California, died of rabies. On October 3, 2000, Canadian public health officials announced that rabies had been confirmed in a 9-year-old boy. The infection might have occurred as a result of interaction with a bat in Quebec approximately a month earlier. On October 4, 2000, officials with the New York State Department of Health announced that rabies had been diagnosed in a citizen of Ghana who had arrived in the United States on September 22, 2000. A village dog bit the patient a few months prior to departure from Ghana. Genetic analysis revealed a variant of the rabies virus typical of those associated with domestic dogs in that region of Africa. On October 13, 2000, the Georgia Department of Human Resources announced that rabies had been diagnosed as the cause of illness for a man who died of encephalitis. On October 25, 2000, a 47-year-old man from Becker County, Minnesota, died of rabies. The man awakened from sleep to find that a bat had alighted on his hand, and he was subsequently bitten.

Genetic analyses revealed variants of the rabies virus associated with rabid Brazilian (Mexican) free-tailed bats (*Tadarida brasiliensis*) to be the cause of the infections in California and Georgia. Variants of the rabies virus associated with rabid silver-haired (*Lasionycteris noctivagans*) and eastern pipistrelle bats (*Pipstrellus subflavus*) were found to be the cause of the rabies infections in Canada and Minnesota.

---

[a]Stobierski MG, Michigan Department of Community Health, Lansing, Mich: Personal communication, 2000.

[b]Smith KA, Ohio Department of Health, Columbus, Ohio: Personal communication, 2000.

[c]Wilson PJ, Texas Department of Health, Austin, Tex: Personal communication, 2000.

References

1. Smith JS, Orciari LA, Yager PA. Molecular epidemiology of rabies in the United States. *Semin Virol* 1995;6:387–400.

2. Krebs JW, Smith JS, Rupprecht CE, et al. Rabies surveillance in the United States during 1998. *J Am Vet Med Assoc* 1999;215:1786–1798.

3. Centers for Disease Control and Prevention. Translocation of coyote rabies—Florida, 1994. *MMWR Morb Mortal Wkly Rep* 1995;44:580–583.

4. Meltzer MI. Assessing the cost and benefits of an oral vaccine for raccoon rabies: a possible model. *Emerg Infect Dis* 1996;2:343–349.

5. Noah DL, Smith MG, Gotthardt JC, et al. Mass human exposure to rabies in New Hampshire: exposure, treatment, and cost. *Am J Public Health* 1996;86:1149–1151.

6. Centers for Disease Control and Prevention. Human rabies—Virginia, 1998. *MMWR Morb Mortal Wkly Rep* 1999;48:95–97.

7. Smith JS. Rabies virus epitopic variation: use in ecologic studies. *Adv Virus Res* 1989;36:215–253.

8. Rupprecht CE, Smith JS. Raccoon rabies: the re-emergence of an epizootic in a densely populated area. *Semin Virol* 1994;5:155–264.

9. Jenkins SR, Perry BD, Winkler WG. Ecology and epidemiology of raccoon rabies. *Rev Infect Dis* 1988;10:S620–S625.

10. Smith JS, Orciari LA, Yager PA, et al. Epidemiologic and historical relationships among 87 rabies virus isolates determined by limited sequence analysis. *J Infect Dis* 1992;166:296–307.

11. Stohr K, Meslin FX. Progress and setbacks in oral immunization of foxes against rabies in Europe. *Vet Rec* 1996;139:32–35.

12. Hanlon CA, Rupprecht CE. The reemergence of rabies. In: Scheld WM, Armstrong D, Hughes JM, eds. *Emerging infections 1*. Washington, DC: American Society for Microbiology, 1998;59–80.

13. Roscoe DE, Holste WC, Sorhage FE, et al. Efficacy of an oral vaccinia-rabies glycoprotein recombinant vaccine in controlling epidemic raccoon rabies in New Jersey. *J Wildl Dis* 1998;34:752–763.

14. Robbins AH, Borden MD, Windmiller BS, et al. Prevention of the spread of rabies to wildlife by oral vaccination of raccoons in Massachusetts. *J Am Vet Med Assoc* 1998;213:1407–1412.

15. Fearneyhough MG, Wilson PJ, Clark KA, et al. Results of an oral rabies vaccination program for coyotes. *J Am Vet Med Assoc* 1998;212:498–502.

16. McGuill MW, Kreindel SM, DeMaria A Jr, et al. Human contact with bait containing vaccine for control of rabies in wildlife. *J Am Vet Med Assoc* 1998;213:1413–1417.

17. Bean NH, Martin SM, Bradford H. PHLIS: an electronic system for reporting public health data from remote sites. *Am J Public Health* 1992;82:1273–1276.

18. Martin SM, Bean NH. Data management issues for emerging diseases and new tools for managing surveillance and laboratory data. *Emerg Infect Dis* 1995;1:124–128.

19. Fischman HR, Grigor JK, Horman JT, et al. Epizootic of rabies in raccoons in Maryland from 1981 to 1987. *J Am Vet Med Assoc* 1992;201:1883–1886.

20. Childs JE, Colby L, Krebs JW, et al. Surveillance and spatiotemporal associations of rabies in rodents and lagomorphs in the United States, 1985–1994. *J Wildl Dis* 1997;33:20–27.

21. Greenwood RJ, Newton WE, Pearson GL, et al. Population and movement characteristics of radio-collared striped skunks in North Dakota during an epizootic of rabies. *J Wildl Dis* 1997;33:226–241.

2. Hanlon CA, Neizgoda M, Hamir AN, et al. First North American field release of a vaccinia-rabies glycoprotein recombinant virus. *J Wildl Dis* 1998;34:228–239.

23. Rupprecht CE, Hanlon CA, Hamir AN, et al. Oral wildlife rabies vaccination: development of a recombinant rabies vaccine. *Trans North Am Wildl Natl Res Conf* 1992;57:439–452.

24. Rupprecht CE, Hanlon CA, Niezgoda M, et al. Recombinant rabies vaccine: efficacy assessment in free ranging animals. *Onderstepoort J Vet Res* 1993;60:463–468.

25. Hanlon CA, Niezgoda M, Shankar V, et al. A recombinant vaccinia-rabies virus in the immunocompromised host: oral innocuity, progressive parenteral infection and therapeutics. *Vaccine* 1997;15:140–148.

26. Clark KA, Neill SU, Smith JS, et al. Epizootic canine rabies transmitted by coyotes in south Texas. *J Am Vet Med Assoc* 1994;204:536–540.

27. Meehan SK. Rabies epizootic in coyotes combated with oral vaccination program. *J Am Vet Med Assoc* 1995;206:1097–1099.

28. Centers for Disease Control and Prevention. Mass treatment of humans exposed to rabies—New Hampshire, 1994. *MMWR Morb Mortal Wkly Rep* 1995;44:484–486.

29. Rotz LD, Hensley JA, Rupprecht CE, et al. Large-scale human exposures to rabid or presumed rabid animals in the United States: 22 cases (1990–1996). *J Am Vet Med Assoc* 1998;212:1198–1200.

30. Krebs JW, Long-Marin SC, Childs JE. Causes, costs, and estimates of rabies postexposure prophylaxis treatments in the United States. *J Public Health Manag Pract* 1998;4:56–62.

31. The NASPHV Committee. Compendium of animal rabies control, 2000. *J Am Vet Med Assoc* 2000;216:338–343.

32. Centers for Disease Control and Prevention. Human rabies prevention—United States, 1999. *MMWR Morb Mortal Wkly Rep* 1999;48:1–21.

33. Muller WW. Oral vaccination of foxes in Europe, 1992. *Rabies Bull Eur* 1992;16:12–13.

34. Macinnes CD. Control of wildlife rabies: the Americas. In: Campbell JB, Charlton KM, eds. *Rabies*. Norwell, Mass: Kluwer Academic Publishers, 1988;381–405.