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Rabies surveillance in the United States during 2007

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Summary—During 2007, 49 states and Puerto Rico reported 7,258 cases of rabies in animals and 1 case in a human to the CDC, representing a 4.6% increase from the 6,940 cases in animals and 3 cases in humans reported in 2006. Approximately 93% of the cases were in wildlife, and 7% were in domestic animals. Relative contributions by the major animal groups were as follows: 2,659 raccoons (36.6%), 1,973 bats (27.2%), 1,478 skunks (20.4%), 489 foxes (6.7%), 274 cats (3.8%), 93 dogs (1.3%), and 57 cattle (0.8%). Compared with numbers of reported cases in 2006, cases in 2007 increased among dogs, bats, foxes, and skunks while decreases were reported among cattle, cats, and skunks. Increases in numbers of rabid raccoons during 2007 were reported by 11 of the 20 eastern states where raccoon rabies was enzootic, and reported cases increased by 1.7% overall, compared with 2006.

On a national level, the number of rabies cases in skunks during 2007 decreased by 1.1% from the number reported in 2006. Texas reported the greatest number (n = 362) of rabid skunks and the greatest overall state total of animal rabies cases (969). No cases of rabies associated with the dog/coyote rabies virus variant were reported. The United States remains free of dog-to-dog transmission of canine rabies virus variants. The total number of cases of rabies reported nationally in foxes increased 14.5%, compared with 2006. Increases in the number of reported rabid foxes were attributable to greater numbers of foxes reported with the Arctic fox rabies virus variant in Alaska, the Texas gray fox rabies virus variant in Texas, and the raccoon rabies virus variant in Virginia. The 1,973 cases of rabies reported in bats represented a 16.6% increase over numbers reported in 2006. Cases of rabies in dogs and in sheep and goats increased 17.7% and 18.2%, respectively, whereas cases reported in cattle, cats, and horses and mules decreased 30.5%, 13.8%, and 20.8%, respectively. In Puerto Rico, reported cases of rabies in mongooses decreased 51.5%, and rabies in domestic animals, presumably attributable to spillover infection from mongooses, increased 25%.

One human rabies case was reported from Minnesota during 2007. Although typing of the rabies virus variant in this case was not possible, an investigation of this case indicated a bat as the most likely source of exposure.

As is the case in many developed countries, wild animals accounted for the majority (93%) of all rabies cases in the United States reported to the CDC during 2007. The most frequently reported rabid wildlife remain raccoons, bats, skunks, and foxes; however, their relative proportions have continued to fluctuate because of epizootics of rabies among animals infected with several distinct rabies virus variants.[1]

Abbreviations

DFA	Direct immunofluorescent antibody
ORV	Oral rabies vaccination
PAHO	Pan American Health Organization
PEP	Postexposure prophylaxis
USDA WS	USDA Wildlife Services
V-RG	Vaccinia-rabies glycoprotein

Rabies virus infections of terrestrial animals in 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 animals occurs but rarely initiates sustained transmission in other species. Once established, enzootic virus transmission within a species can persist regionally for decades or longer.

Rabies virus variants can be identified antigenically by reaction with panels of monoclonal antibodies[2] or by comparing patterns of nucleotide substitution

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determined by genetic analysis.[1,3] The spatial boundaries of enzootic rabies in reservoir species are temporally dynamic (**Figure 1**). Affected areas may expand and contract through virus transmission and population interactions.[4,5] Population increases and emigration result in the expansion of rabies-infected areas, whereas natural barriers, such as mountain ranges and bodies of water, may restrict animal movements or sustain lower population densities that slow the spread of rabies. Unusual animal dispersal patterns and human-mediated translocation of infected animals have resulted in more rapid and unexpected introductions of rabies into new areas.[1,3–7]

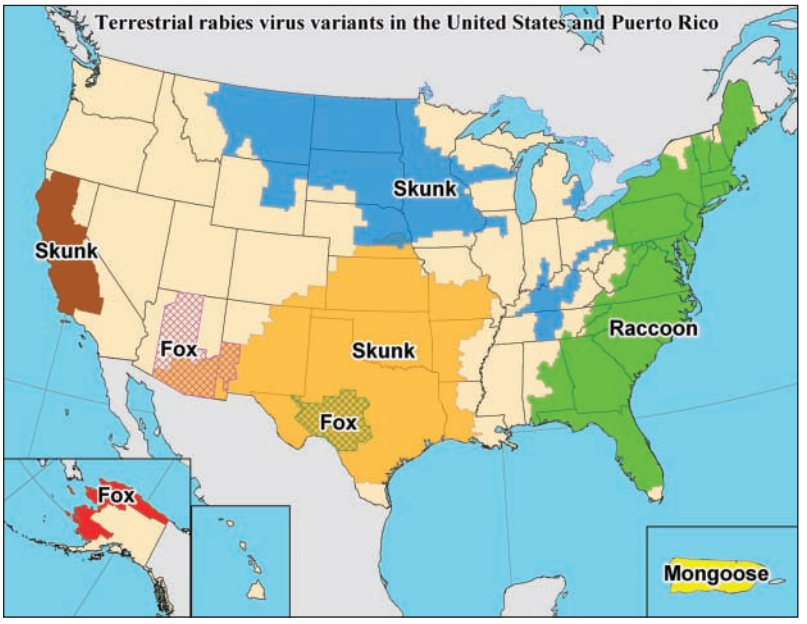

Figure 1—Distribution of major rabies virus variants among wild terrestrial reservoirs in the United States and Puerto Rico, 2007.

Rabies control programs, including extensive vaccination campaigns implemented during the 1940s and 1950s, resulted in a substantial decline of rabies in domestic animals in the United States and eliminated the circulation of the major canine variants of the rabies virus in dogs (*Canis lupus familiaris*) by the late 1960s (**Figure 2**). During the late 1980s, a canine rabies virus variant reemerged in south Texas. This virus had been maintained historically in coyotes (*Canis latrans*) and transmitted to unvaccinated dogs. Oral rabies vaccination programs were initiated to interrupt transmission of this rabies virus variant. No cases of animals infected with this rabies virus variant have been reported since 2004.[8] After more than 10 years of oral vaccination, this variant has now been eliminated from the United States.[9–12] Rabies cases associated with a second canid rabies virus variant found mainly in gray foxes (*Urocyon cinereoargenteus*) in west and central Texas have similarly been reduced. Regulations in place in Texas and other states prohibiting the translocation of certain wild animal species for hunting and restocking purposes may have reduced the likelihood of accidental introduction of rabies virus variants into unaffected areas.[1,6,7]

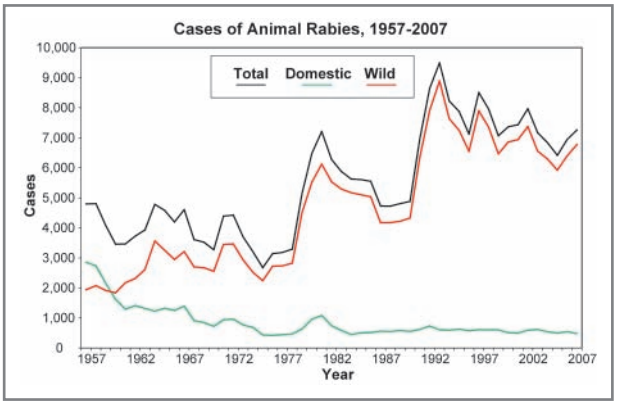

Figure 2—Cases of animal rabies in the United States, by year, 1957 to 2007.

Raccoons (*Procyon lotor*) have been recognized as a major 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.[13] Although identifiable as separate foci prior to 1994, the mid-Atlantic and southeastern fronts merged in North Carolina in 1995. Raccoon rabies is now enzootic in all of the eastern coastal states as well as in Alabama, Ohio, Pennsylvania, Tennessee, Vermont, and West Virginia.

Three rabies virus variants are responsible for disease in skunks (primarily *Mephitis mephitis*) in California and the north central and south central United States. In Alaska, a long-standing reservoir for rabies virus exists in red and arctic foxes (*Vulpes vulpes* and *Alopex lagopus*, respectively). Rabies spread during the 1950s among red foxes across Canada and, intermittently, to foxes in adjoining areas of the New England states. Although rabies persists in foxes in Alaska, reports of rabid foxes have declined in Canada, in part because of ORV programs.[14] Two rabies virus variants are in geographically limited populations of gray foxes (*U cinereoargenteus*) in Arizona and Texas. On the island of Puerto Rico, another wildlife rabies reservoir exists in mongooses (*Herpestes javanicus*).[15,16] Rabies virus maintained and circulated by mongooses is periodically transmitted to unvaccinated dogs and cats.[6]

Distribution of an oral V-RG recombinant vaccine targeting raccoons in the eastern United States[17–19] and gray foxes and coyotes in Texas[12] has shown promise as an important adjunct to traditional rabies control methods (ie, parenteral vaccination of domestic animals). Biologics used in oral vaccination programs are self-replicating, and the unintentional exposure of nontarget species, including humans, must be minimized and monitored.[20,21]

Multiple, independent reservoirs for rabies virus exist in several species of insectivorous bats, overlaying the patterns of rabies virus variants maintained among terrestrial mammals. Rabies virus transmission among

bats appears to be primarily intraspecific, and distinct virus variants can be identified and associated with 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 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, such transmission rarely results in sustained, independent, intraspecific cycles among terrestrial animals. Such occurrences represent significant shifts in host adaptation and the emergence of rabies virus variants in a new host species. In 2001, this rare phenomenon was demonstrated by the adaptation of a rabies virus variant associated with big brown bats (*Eptesicus fuscus*) in Flagstaff, Ariz, to skunks (*M mephitis*) in an area previously naive for terrestrial rabies.[22] Prior genetic analysis indicated a net difference 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 detectable, as is sustained transmission of a bat-associated rabies virus variant in a terrestrial mammal population.

Various public health activities, including vaccination of companion animals, vaccination programs targeting wildlife, and ongoing education programs, have contributed to the reduction in transmission of rabies virus from terrestrial animals to humans.[23] However, the majority of cases in humans have resulted from infection with rabies virus variants that are associated with bats.[24,25] Rabies control in bats is difficult by conventional methods. Prevention of rabies in humans resulting from infection with bat-associated rabies virus variants is further challenged by the frequent absence of documented exposure histories involving a bat bite.

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 in 1957. For this report, short-term trends were determined by comparing reported cases from 2007 with those from 2006 and by examining seasonal patterns for selected species.

Summaries of 2007 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 2008 is also included.

Collection of Data

Data collection procedures were similar to those described previously.[8] Between January 1 and December 31, 2007, all 50 states, New York City, the District of Columbia, and Puerto Rico reported, on a monthly basis, the number of cases of rabies in animals to the CDC by county of origin and type of animal. Typically, epidemiologic data are provided for all animals tested. During 2007, all states submitted data for all animals tested. County of origin for animals testing negative from the state of Oklahoma was not reported. A total of 120,897 animals were reported to the CDC as tested in the United States during 2007, accounting for a 7.0% increase in number of animals tested from 2006.

State public health laboratories report rabies cases among most terrestrial mammals using the common name 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 (eg, *Chiroptera* = bats). Several states reported data by use of the Public Health Laboratory Information System or their Laboratory Information Tracking System.[26,27] Existing public health reporting systems were not designed for transmission of data involving diseases in animal populations and often lack designated fields for reporting vital information such as animal species.[28,29] To facilitate consistent reporting, all states and territories are requested to submit finalized data directly to the Poxvirus and Rabies Branch at CDC. All year-end totals were confirmed by e-mail or telephone verification with state or territorial health department officials. Data from Canada were obtained from the Animal Health Division, Canadian Food Inspection Agency, and data from Mexico were obtained from the PAHO Epidemiological Information System (SIEPI).[30]

Diagnosis in animals suspected of having rabies was made by DFA staining of rabies viral antigen in brain material submitted to state health laboratories as described in the standard DFA protocol for rabies.[31] Virus isolation in neuroblastoma cell cultures or mice, nucleic acid detection via the reverse transcriptase–PCR assay, and sequencing and genetic analysis were used to confirm some cases.

Calculations of percentage positive are based on the total number of animals tested for rabies. Because most animals submitted for testing are selected because of abnormal behavior or obvious illness, the percentage positive presented is not representative of the incidence of rabies in the general species population. Furthermore, because of differences in proto-

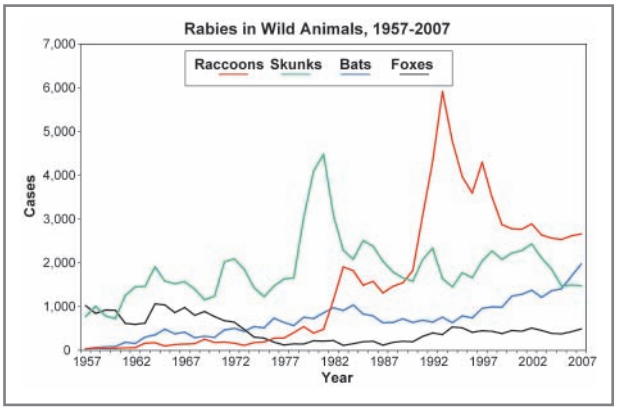

Figure 3—Cases of rabies in wild animals in the United States, by year and species, 1957 to 2007.

Table 1—Cases of rabies in the United States, by state and category, during 2007.

				Domestic animals						Wild animals									
State (city)	Total cases	Domestic	Wild	Cats	Cattle	Dogs	Horses/ mules	Sheep/ goats	Other domestic*	Raccoons	Bats	Skunks	Foxes	Other wild†	Rodents and lagomorphs‡	Humans	% Positive 2007	2006 cases	Change (%)
AK	45	3	42	0	0	3	0	0	0	0	0	0	41	1[d]	0	0	44.6	18	150.00
AL	156	1	155	0	0	1	0	0	0	93	40	0	20	2[e]	0	0	6.2	82	90.24
AR	33	2	31	0	1	1	0	0	0	0	7	23	1	0	0	0	4.0	32	3.13
AZ	159	0	159	0	0	0	0	0	0	0	115	13	24	7[f]	0	0	6.4	140	13.57
CA	188	1	187	1	0	0	0	0	0	2	152	26	6	1[g]	0	0	2.8	202	–6.93
CO	56	0	56	0	0	0	0	0	0	0	51	4	0	1[h]	0	0	6.0	70	–20.00
CT	219	7	212	7	0	0	0	0	0	147	33	30	1	0	1[x]	0	8.4	208	5.29
DC	43	2	41	2	0	0	0	0	0	29	11	0	1	0	0	0	13.0	40	7.50
DE	11	3	8	3	0	0	0	0	0	4	0	3	1	0	0	0	5.6	24	–54.17
FL	251	29	222	26	0	1	2	0	0	128	36	4	38	16[i]	0	0	4.2	176	42.61
GA	301	31	270	16	2	10	2	1	0	193	18	35	18	5[j]	1[y]	0	13.5	268	12.31
HI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0.00
IA	31	13	18	7	0	5	1	0	0	0	13	5	0	0	0	0	1.9	57	–45.61
ID	12	0	12	0	0	0	0	0	0	0	12	0	0	0	0	0	2.4	26	–53.85
IL	113	0	113	0	0	0	0	0	0	0	113	0	0	0	0	0	2.2	46	145.65
IN	13	0	13	0	0	0	0	0	0	0	12	1	0	0	0	0	0.7	13	0.00
KS	110	24	86	11	8	0	3	2	0	0	13	73	0	0	0	0	8.6	83	32.53
KY	20	10	10	2	0	5	3	0	0	0	6	4	0	0	0	0	2.0	30	–33.33
LA	6	2	4	0	0	1	1	0	0	0	3	1	0	0	0	0	0.8	7	–14.29
MA	152	8	144	7	0	1	0	0	0	71	28	38	3	2[k]	2[z]	0	5.7	232	–34.48
MD	431	25	406	19	3	3	0	0	0	253	54	41	49	2[l]	7[aa]	0	9.2	414	4.11
ME	86	3	83	3	0	0	0	0	0	38	9	31	4	0	1[bb]	0	11.6	127	–32.28
MI	210	4	206	2	0	1	1	0	0	0	199	5	2	0	0	0	5.7	50	320.00
MN	40	3	36	1	1	1	0	0	0	0	18	18	0	0	0	1	1.7	42	–4.76
MO	38	1	37	0	0	0	1	0	0	0	33	4	0	0	0	0	1.3	66	–42.42
MS	3	0	3	0	0	0	0	0	0	0	3	0	0	0	0	0	1.1	9	–66.67
MT	23	4	19	0	0	3	0	0	1[a]	0	13	6	0	0	0	0	4.4	16	43.75
NC	474	36	438	21	5	4	4	2	0	245	34	98	58	3[m]	0	0	12.1	521	–9.02
ND	30	16	14	4	2	7	2	1	0	1	2	11	0	0	0	0	8.6	32	–6.25
NE	31	4	27	1	1	1	1	0	0	0	14	13	0	0	0	0	3.5	34	–8.82
NH	54	2	52	1	0	0	0	0	1[b]	22	9	17	2	0	2[cc]	0	9.1	48	12.50
NJ	283	23	260	18	1	1	2	1	0	163	54	28	8	1[n]	6[dd]	0	8.3	265	6.79
NM	17	1	16	0	1	0	0	0	0	0	4	2	9	1[o]	0	0	4.5	10	70.00
NV	9	0	9	0	0	0	0	0	0	0	9	0	0	0	0	0	2.8	8	12.50
NY	512	20	492	17	0	1	2	0	0	279	104	75	25	3[p]	6[ee]	0	5.6	612	–16.34
NYC	47	3	44	3	0	0	0	0	0	40	0	3	0	0	1[ff]	0	5.7	44	6.82
OH	86	0	86	0	0	0	0	0	0	11	66	9	0	0	0	0	1.9	59	45.76
OK	78	17	61	4	7	4	0	2	0	0	4	57	0	0	0	0	5.7	69	13.04
OR	12	0	12	0	0	0	0	0	0	0	12	0	0	0	0	0	4.2	25	–52.00
PA	439	38	401	26	7	2	2	1	0	273	34	62	17	6[q]	9[gg]	0	5.1	504	–12.90
PR	47	15	32	4	0	9	2	0	0	0	0	0	0	32[r]	0	0	28.8	78	–39.74
RI	45	3	42	2	0	0	1	0	0	21	3	14	2	1[s]	1[hh]	0	11.3	30	50.00
SC	162	12	150	7	2	3	0	0	0	92	10	14	32	2[t]	0	0	7.0	180	–10.00
SD	27	7	20	2	2	2	0	1	0	0	4	16	0	0	0	0	4.3	38	–28.95
TN	132	7	125	1	1	5	0	0	0	21	22	82	0	0	0	0	5.9	131	0.76
TX	969	41	928	14	4	12	9	1	1[c]	17	482	362	32	35[u]	0	0	6.4	890	8.88
UT	16	0	16	0	0	0	0	0	0	0	16	0	0	0	0	0	2.9	11	45.45
VA	730	50	680	36	8	5	1	0	0	359	30	185	90	5[v]	11[ii]	0	16.4	637	14.60
VT	165	5	160	2	1	0	1	1	0	103	3	49	3	1[w]	1[jj]	0	16.2	73	126.03
WA	22	0	22	0	0	0	0	0	0	0	22	0	0	0	0	0	3.8	15	46.67
WI	26	1	25	0	0	1	0	0	0	0	25	0	0	0	0	0	1.2	22	18.18
WV	77	4	73	4	0	0	0	0	0	54	4	12	2	0	1[kk]	0	6.9	118	–34.75
WY	19	1	18	0	0	0	1	0	0	0	14	4	0	0	0	0	2.6	11	72.73
Total	**7,259**	**482**	**6,776**	**274**	**57**	**93**	**42**	**13**	**3**	**2,659**	**1,973**	**1,478**	**489**	**127**	**50**	**1**	**6.0**	**6,943**	**4.55**
% 2007	100.00	6.64	93.35	3.77	0.79	1.28	0.58	0.18	0.04	36.63	27.18	20.36	6.74	1.75	0.69	0.01			
% Pos 2007	6.00	0.78	11.51	0.86	4.87	0.34	4.26	2.61	0.91	17.74	6.58	26.66	28.71	4.26	1.36	—			
Total 2006	6,943	547	6,393	318	82	79	53	11	4	2,615	1,692	1,494	427	121	44	3			
% Change	4.55	–11.88	5.99	–13.84	–30.49	17.72	–20.75	18.18	–25.00	1.68	16.61	–1.07	14.52	4.96	13.64	–66.67			

*Other domestic includes: [a]1 swine; [b]1 swine; [c]1 swine. †Other wild includes: [d]1 wolf; [e]2 opossums; [f]6 bobcats, 1 coyote; [g]1 coyote; [h]1 coyote; [i]8 bobcats, 8 otters; [j]3 bobcats, 1 coyote, 1 otter; [k]1 bobcat, 1 coyote; [l]1 bear, 1 otter; [m]3 coyotes; [n]1 coyote; [o]1 bobcat; [p]2 deer, 1 fisher; [q]2 bobcats, 4 deer; [r]32 mongooses; [s]1 coyote; [t]2 bobcats; [u]12 bobcats, 21 coyotes, 1 opossum, 1 wolf hybrid; [v]3 bobcats, 2 coyotes; [w]1 bobcat. ‡Rodents and lagomorphs include: [x]1 groundhog; [y]1 groundhog; [z]2 groundhogs; [aa]1 beaver, 6 groundhogs; [bb]1 groundhog; [cc]2 groundhogs; [dd]1 beaver, 5 groundhogs; [ee]6 groundhogs; [ff]1 groundhog; [gg]9 groundhogs; [hh]1 groundhog; [ii]2 beavers, 9 groundhogs; [jj]1 groundhog; [kk]1 groundhog.

% Pos = (Total number positive/total number tested) X 100. — = Not calculated.

cols for submitting animals of various species as well as differing policies from state to state, the percentage positive for 1 species is not directly comparable among species, and comparison of percentage positive among states is inappropriate. For comparison of percentage positive to historical data, data from states lacking total submission data were excluded from calculations.

The geographic areas for various rabies virus reservoirs in the United States were produced by aggregating data from 2003 through 2007. If no cases of a

particular variant were identified over the preceding 2 years, the variant is not represented. County boundaries where cases were reported in the reservoir species over this period were dissolved by means of a software program[a] to produce a single polygon representing the distribution of that rabies virus variant. Reservoir maps are an estimate of the relative distribution of each major terrestrial rabies virus variant maintained by a particular reservoir species. Because of the paucity of samples tested at some localities and a lack of antigenic typing or genetic sequencing where reservoirs meet, defining precise viral fronts is difficult. Geographic location was provided only to the county level, and maps represent cases at this jurisdictional level. Submission data for Oklahoma were not provided with location data.

Rabies in Wild Animals

Wild animals accounted for 6,776 (93.4%) of the 7,258 reported cases of rabies in 2007 (**Figure 3**). This number represents a 6% increase from the 6,393 cases reported in 2006 (**Table 1**). Raccoons continued to be the most frequently reported rabid wildlife species (36.6% of all animal cases during 2007), followed by bats (27.2%), skunks (20.4%), foxes (6.7%), and other wild animals, including rodents and lagomorphs (2.4%). Numbers of reported cases in raccoons, bats, and foxes increased 1.7%, 16.6%, and 14.5%, respectively, from 2006 totals. Reported cases in skunks decreased 1.1%, compared with 2006.

Raccoons—The 2,659 cases of rabies in raccoons (*P lotor*) reported in 2007 represented a continued increase from 2006 after 3 years of decline (Table 1). However, the percentage of raccoons testing positive declined from 18.7% in 2006 to 17.7% in 2007. Increases in numbers of rabid raccoons during 2007 were reported by 11 of the 20 eastern states where raccoon rabies is enzootic, including Tennessee (600.0% increase; 3 cases in 2006 to 21 cases in 2007), Vermont (145.2%; 42 to 103), Alabama (66.1%; 56 to 93), Connecticut (31.2%; 112 to 147), Rhode Island (31.25%; 16 to 21), Georgia (25.3%; 154 to 193), New Jersey (17.3%; 139 to 163), New Hampshire (15.8%; 19 to 22), Virginia (15.4%; 311 to 359), Florida (15.3%; 111 to 128), and Ohio (10.0%; 10 to 11; **Figure 4**). The District of Columbia (11.5% increase; 26 cases in 2006 to 29 cases in 2007) and New York City (11.1%; 36 to 40) also reported increases. Nine states with well-documented enzootic raccoon rabies reported decreases in the number of rabid raccoons, including Delaware (75.0% decrease; 16 cases in 2006 to 4 cases in 2007), Massachusetts (47.4%; 135 to 71), Maine (35.6%; 59 to 38), West Virginia (26.0%; 73 to 54), North Carolina (17.5%; 297 to 245), New York (12.8%; 320 to 279), South Carolina (12.4%; 105 to 92), Maryland (7.0%; 272 to 253), and Pennsylvania (3.5%; 283 to 273). The states of the northeast/mid-Atlantic focus of the raccoon rabies epizootic, consisting of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, Virginia, and West Virginia as well as the District of Columbia and New York City, accounted for 70.2% (1,867 cases; 0.1% decrease) of the 2,659 total rabies cases in raccoons in 2007. The southeastern states of Alabama, Florida, Georgia, North Carolina, South Carolina, and Tennessee reported 29.0% (772 cases; 6.3% increase) of the total cases in raccoons. States enzootic for raccoon rabies reported 99.2% (2,639/2,659) of all documented cases of rabies in raccoons and accounted for 65.1% (4,724/7,258) of the national total of rabid animals (78.4% [4,144/5,285] of total cases in terrestrial animals). This represents a decrease in the total proportion of animals presumably infected with the raccoon rabies virus variant, compared with 2006.

Eleven cases of rabies in raccoons infected with the raccoon rabies virus variant were reported from Ohio. Ten of these occurred in 2 of the 3 counties reported in 2006 (Lake and Cuyahoga).[32] An additional case occurred on the Ohio-Pennsylvania border in Mahoning County, Ohio. Rabid raccoons reported by Texas (17), California (2), and North Dakota (1) were presumably the result of spillover infection from local terrestrial reservoirs (Texas: 1 because of Texas gray fox rabies virus variant, 14 south central skunk rabies virus variant, 2 untyped; California: 2 because of bat rabies virus variants; North Dakota: 1 untyped).

Bats—Rabies in bats accounted for 27.2% of all cases of rabies in animals reported in 2007 (Table 1). The 1,973 cases reported in 2007 represented an increase of 16.6% over those reported in 2006. Total percentage positive of tested bats also increased during 2007 from 6.3% in 2006 to 6.6%. Rabies in bats is widely distributed throughout the United States, with cases reported from all 48 contiguous states (**Figure 5**). Six states re-

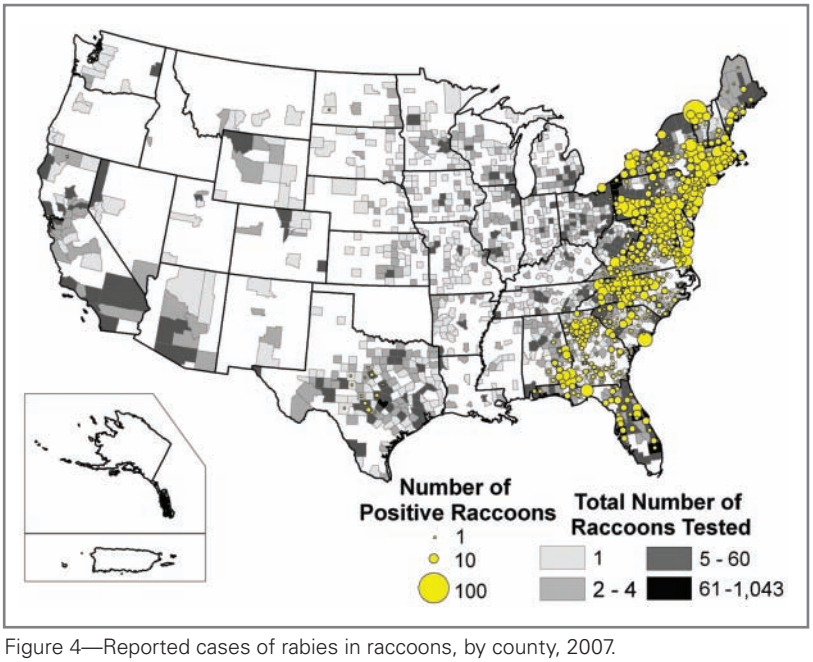

Figure 4—Reported cases of rabies in raccoons, by county, 2007.

ported > 100 cases of rabies in bats: Texas (482; 24.4%), Michigan (199; 10.0%), California (152; 7.7%), Arizona (115; 5.8%), Illinois (113; 5.7%), and New York (104; 5.3%). Seven states (Idaho, Illinois, Mississippi, Nevada, Oregon, Utah, and Washington) reported rabies in bats but not in terrestrial mammals. Alaska, Delaware, Hawaii, New York City, and Puerto Rico did not report any cases of bat rabies during 2007. Of the bats infected with rabies virus, 35.3% (696/1,973) were identified beyond the taxonomic level of order (13 to genus and 683 to species). Among bats identified beyond taxonomic level of order, 67.6% (471/696) were *E fuscus*, the big brown bat; 9.2% (64/696) were *Tadarida brasiliensis*, the Brazilian (Mexican) free-tailed bat; 5.9% (41/696) were *Pipistrellus hesperus*, the western pipistrelle; 4.3% (30/696) were *Myotis lucifugus*, the little brown bat; 3.3% (23/696) were *Lasiurus borealis*, the red bat; 2.3% (16/696) were *Lasiurus cinereus*, the hoary bat; 2.3% (16/696) were *Lasionycteris noctivagans*, the silver-haired bat; 0.4% (3/696) were *Antrozous pallidus*, the pallid bat; 0.4% (3/696) were *Myotis californicus*, the California myotis; 0.4% (3/696) were *Myotis septentrionalis*, the northern long-eared myotis; 0.3% (2/696) were *Lasiurus seminolus*, the Seminole bat; 0.3% (2/696) were *Lasiurus xanthinus*, the western yellow bat; 0.3% (2/696) were *Macrotus californicus*, the California leafnosed bat; 0.1% (1/696) were *Lasiurus ega*, the southern yellow bat; 0.1% (1/696) were *Myotis evotis*, the long-eared myotis; 0.1% (1/696) were *Myotis grisescens*, the gray myotis; 0.1% (1/696) were *Myotis velifer*, the cave myotis; 0.1% (1/696) were *Myotis yumanesis*, the Yuma myotis; 0.1% (1/696) were *Nycticeius humeralis*, the evening bat; and 0.1% (1/696) were *Pipistrellus subflavus*, the eastern pipistrelle. Unspeciated bats of the genus *Myotis* (13/696) accounted for the remaining rabid bats and contributed 1.9% to the total of bats identified beyond the taxonomic level of order. Not all public health laboratories had the capacity to speciate bats. Among test-positive bats for which a species was provided, more solitary species (*L borealis*, *L cinereus*, *L ega*, *L seminolus, L xanthinus*, *M californicus, P hesperus*, and *P subflavusi*) had a significantly higher proportion of rabid animals than colonial species (12.6%, compared with 5.4%, respectively; $P < 0.0001$).

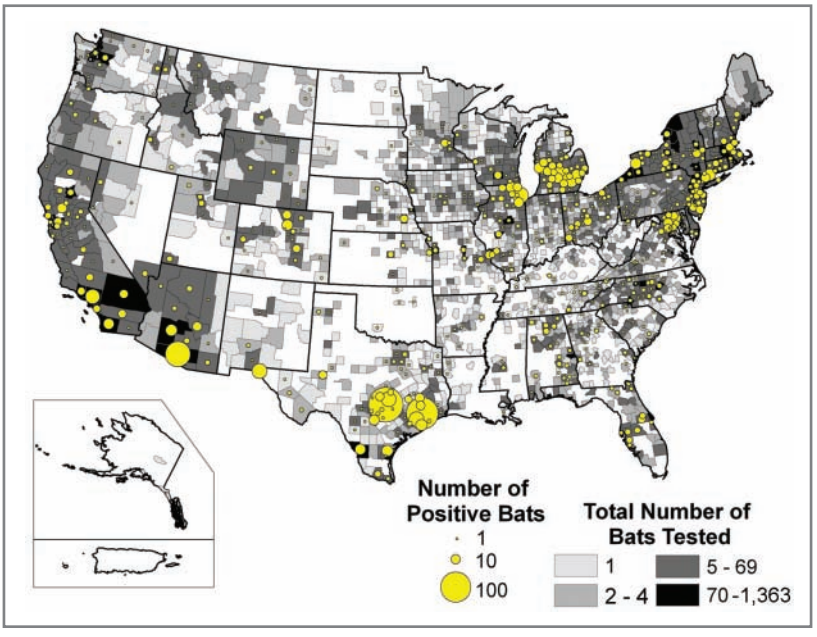

Figure 5—Reported cases of rabies in bats, by county, 2007.

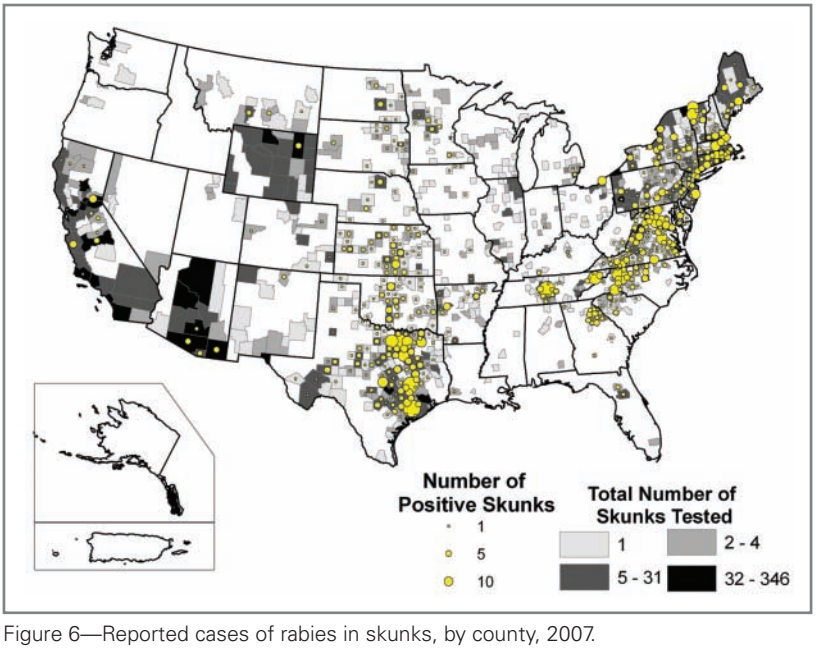

Figure 6—Reported cases of rabies in skunks, by county, 2007.

Skunks—The 1,478 reported cases of rabies in skunks (mainly *M mephitis*) in 2007 represented a 1.1% decrease from the number reported in 2006 (**Figure 6**; Table 1). Total percentage of skunks that tested positive decreased from 28.1% positive in 2006 to 26.7% positive in 2007. Ten of the 24 states where a skunk rabies virus variant is enzootic reported increased numbers of rabid skunks during 2007, including Kansas (37.7% increase; 53 cases in 2006 to 73 cases in 2007), Wyoming (33.3%; 3 to 4), Arkansas (27.8%; 18 to 23), Michigan (25.0%; 4 to 5), Montana (20.0%; 5 to 6), Oklahoma (14.0%; 50 to 57), and Texas (3.1%; 351 to 362). Ohio and Indiana reported no cases of rabies in skunks during 2006, but reported 9 (all raccoon rabies virus variant) and 1 case, respectively, during 2007. Two states where skunk rabies virus variants are enzootic reported decreases > 50% during 2007: Kentucky (55.6% decrease; 9 cases in 2006 to 4 cases in 2007) and Iowa (61.5%; 13 to 5). Wisconsin reported no cases of rabies in skunks in 2007, but reported 1 case in 2006.

States in which the raccoon rabies virus variant is enzootic (excluding Tennessee, where skunks are the predominant reservoir) reported 50.6% (748/1,478) of the cases of rabies in skunks, the majority of which were presumably the result of spillover infection of the virus from raccoons. Among the 19 states where the raccoon rabies virus variant is the predominant terrestrial reservoir of rabies, 8 states and New York City reported increases in the number of rabid skunks, including Ohio (900.0%; 0 cases in 2006 to 9 cases in 2007), Florida (300.0%; 1 to 4), Delaware (200.0%; 1 to 3), Vermont (104.2%; 24 to 49), Rhode Island (100.0%; 7 to 14), Maryland (51.8%; 27 to 41), New York City (50.0%; 2 to 3), Virginia (18.6%; 156 to 185), and North Carolina (7.8%; 91 to 98).

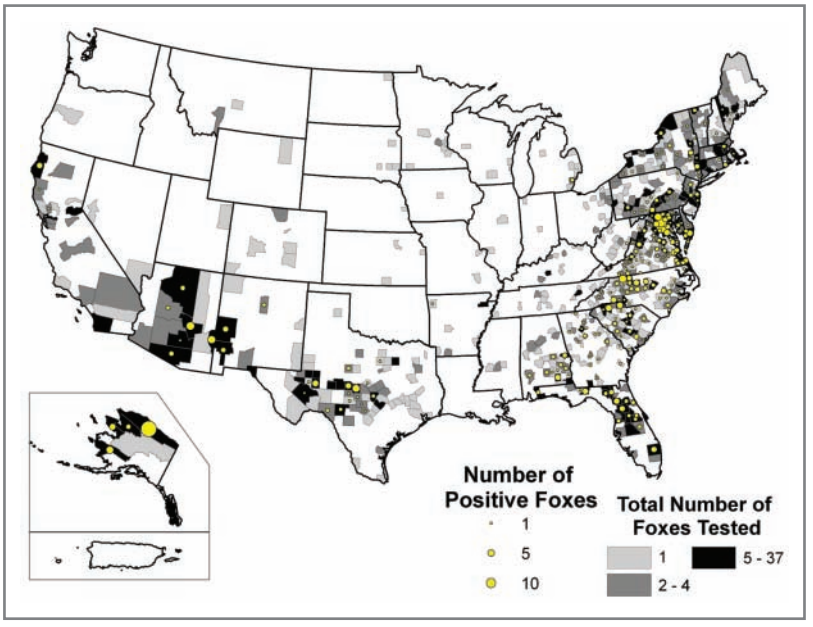

Figure 7—Reported cases of rabies in foxes, by county, 2007.

Foxes—Foxes (mainly *V vulpes*, *U cinereoargenteus*, or *A lagopus*) accounted for 6.7% of all cases of rabies in animals reported in 2007 (Table 1). The 489 cases of rabies in foxes represented a 14.5% increase from 2006. The percentage of test-positive foxes submitted for testing during 2007 (28.7%) also increased from that reported in 2006 (24.9%). Most cases of rabies in foxes (374; 76.5%) were reported by states affected predominantly by the raccoon rabies virus variant **(Figure 7)**. Sixteen states reported increases in the number of rabid foxes, compared with 2006: Alaska (241.7% increase; 12 cases in 2006 to 41 cases in 2007), Vermont (200.0%; 1 to 3), California (200.0%; 2 to 6), Alabama (185.7%; 7 to 20), Maine (100.0%; 2 to 4), Michigan (100.0%; 1 to 2), Florida (40.7%; 27 to 38), South Carolina (23.1%; 26 to 32), Maryland (19.5%; 41 to 49), North Carolina (16.0%; 50 to 58), Georgia (12.5%; 16 to 18), Virginia (12.5%; 80 to 90), Arizona (9.1%; 22 to 24), and Texas (3.2%; 31 to 32). New Mexico and Arkansas reported no cases of rabies in foxes during 2006 but reported 9 and 1 case, respectively, during 2007. Utah and Tennessee reported cases of rabies in foxes in 2006, but no cases in 2007.

Other wild animals—Puerto Rico reported 32 rabid mongooses (*H javanicus*) during 2007, a 51.5% decrease from the 66 cases reported in 2006 (Table 1). Other wildlife in which rabies was reported included 46 groundhogs (*Marmota monax*), 39 bobcats (*Lynx rufus*), 33 coyotes (*C latrans*), 10 river otters (*Lontra canadensis*), 6 white-tail deer (*Odocoileus virginianus*), 4 beavers (*Castor canadensis*), 3 opossums (*Didelphis virginiana*), 1 bear (*Ursus americanus*), 1 fisher (*Martes pennanti*), 1 wolf (*C lupus*), and 1 wolf hybrid. All cases of rabies in rodents and lagomorphs were reported by states in which rabies is enzootic in raccoons.

Of the 33 coyotes test positive for rabies, 29 were variant typed. Variant information was unavailable from New Jersey (1), Texas (1), and Virginia (2). All test-positive coyotes for which variant typing results were available were infected with the predominant terrestrial rabies virus variant for the geographic region where the animal was found (19 Texas gray fox rabies virus variant, 6 raccoon rabies virus variant, 2 south central skunk rabies virus variant, 1 California skunk rabies virus variant, and 1 Arizona gray fox rabies virus variant).

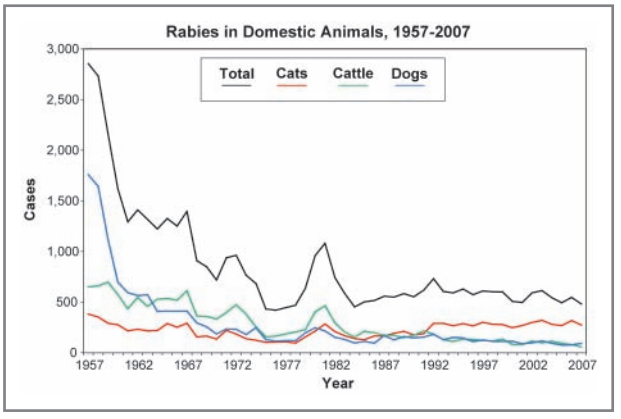

Figure 8—Cases of rabies in domestic animals in the United States, by year, 1957 to 2007.

Rabies in Domestic Animals

Domestic species accounted for 6.6% of all rabid animals reported in the United States in 2007 (Table 1). The number of domestic animals reported rabid in 2007 (482) represented an 11.9% decrease from the total reported in 2006 **(Figure 8)**. Reported cases of rabies in cats, cattle, and horses decreased 13.8%, 30.5%, and 20.8%, respectively. Reported cases of rabies in dogs increased 17.7%, compared to 2006. Virginia reported the largest number of rabid domestic animals (50 cases), followed by Texas (41), Pennsylvania (38), North Carolina (36), and Georgia (31).

Cats—Most (221) of the 274 cases of rabies in cats were reported from states in which the raccoon rabies virus variant is present **(Figure 9)**. Remaining

cases were reported principally by Central Plains states, where most cases were presumably the result of spillover from rabid skunks. Ten states reported > 10 cases of rabies in cats (Virginia, 36 cases; Florida, 26; Pennsylvania, 26; North Carolina, 21; Maryland, 19; New Jersey, 18; New York, 17; Georgia, 16; Texas, 14; and Kansas, 11). Twenty-one states did not report any rabid cats. Puerto Rico reported 4 cases of rabies in cats, presumably spillover from the mongoose rabies virus variant.

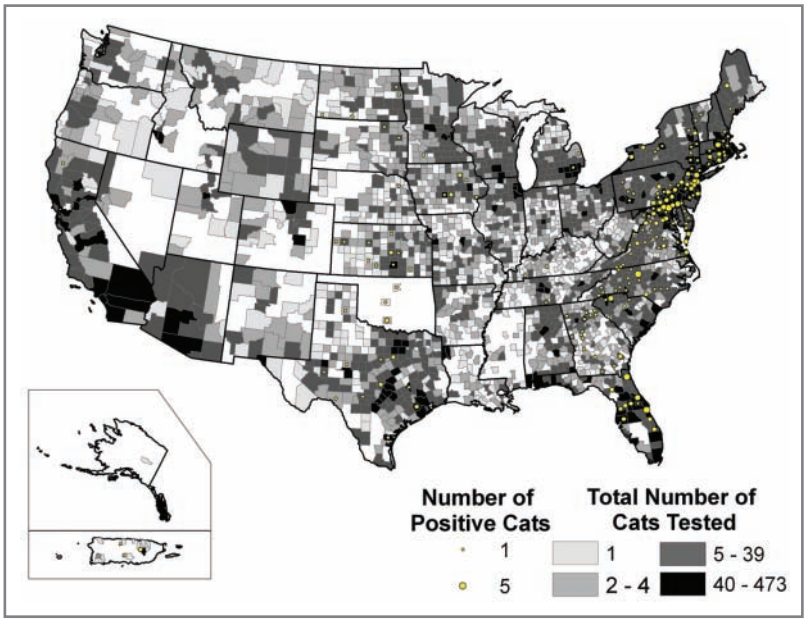

Figure 9—Reported cases of rabies in cats, by county and municipio (Puerto Rico), 2007.

Dogs—Texas (12 cases), Georgia (10), and North Dakota (7) reported the largest numbers of cases of rabies in dogs by individual states (**Figure 10**). No other states reported > 5 cases of rabies in dogs in 2007. No cases were reported involving the dog/coyote rabies virus variant. Twenty-four states, the District of Columbia, and New York City did not report any rabid dogs. Puerto Rico reported 9 cases of rabies in dogs. One case was reported from Juneau, Alaska, which was in a dog imported from India.[33]

Excluding rabid dogs from Puerto Rico (which are presumably because of the mongoose rabies virus variant), 84 cases of rabies in dogs were reported from the United States. Of those 84 cases, 58% (n = 49) were typed by monoclonal antibodies or sequenced to determine the rabies virus variant responsible. One dog in Ward County, Tex, was determined to be infected with a rabies virus variant associated with Mexican free-tailed bats (*T brasiliensis*), and 1 dog in Suwanee County, Fla, was infected with the rabies virus variant associated with red bats (*L borealis*). The rabies virus variants isolated from all other positive dogs typed in 2007 were identified as the terrestrial rabies virus variant associated with the geographic area where the dog was collected (Figure 3). Four samples could not be confirmed positive or contained insufficient antigen for typing. Typing results were not provided from Georgia (8/10 test-positive dogs not typed), Iowa (1/ 5), Louisiana (1/1), Maryland (3/3), Montana (1/3), North Carolina (1/4), North Dakota (7/7), Nebraska (1/1), Oklahoma (4/4), Pennsylvania (2/2), South Dakota (2/2), and Virginia (4/5).

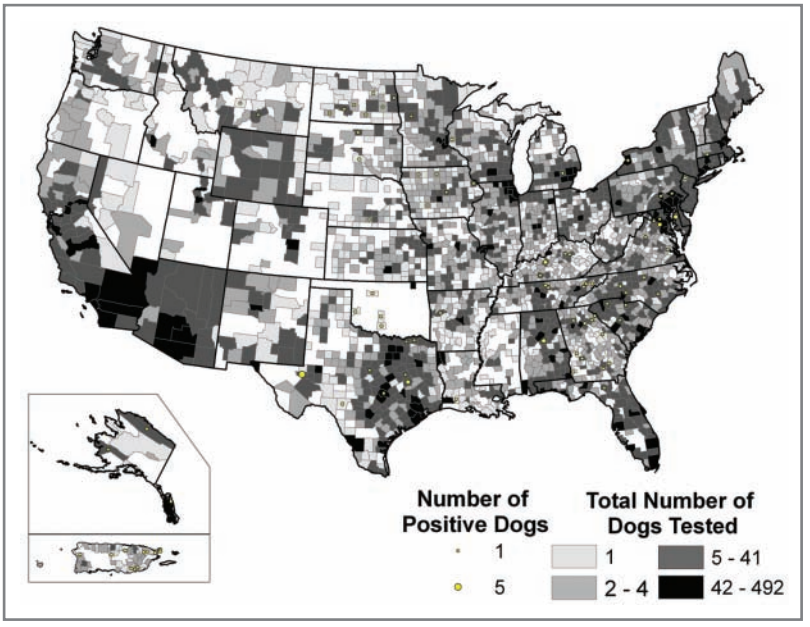

Figure 10—Reported cases of rabies in dogs, by county and municipio (Puerto Rico), 2007.

Other domestic animals—The number of cases of rabies in cattle decreased 30.5% from 82 in 2006 to 57 in 2007 (**Figure 11**; Table 1). Distribution of rabid cattle was similar to that of rabid skunks in the Central and Midwestern states (Figures 6 and 11) and to rabid raccoons in the mid-Atlantic/northeastern region (Figures 4 and 11). Kansas (8 cases), Virginia (8), Oklahoma (7), and Pennsylvania (7) reported the largest numbers of rabid cattle. No other state reported > 5 cases of rabies in cattle in 2007. The 42 cases of rabies reported in horses and mules (including donkeys) in 2007 represented a 20.8% decrease from the 53 cases reported in 2006. Reported cases of rabies in sheep and goats increased 18.2% from 11 cases in 2006 to 13 cases in 2007. Other reported cases of rabies in domestic animals included 3 pigs (in Montana, New Hampshire, and Texas).

Seasonal Trends

The mean numbers of animals reported with rabies by month and species were examined from 2003 to 2007. The

frequency of reported cases of rabies in raccoons had an early peak in March and May followed by a brief decline until a slightly higher peak was observed in August and September (**Figure 12**). Reporting for rabid skunks followed a similar seasonal trend. Reports of rabid bats increased from January to a peak in August before a steep decline through December. The frequency of reported rabid foxes had a gradual increase and decline with a peak in May.

Reported cases in cats fluctuated from January until April, before abruptly increasing to a peak during June and July, followed by a steady decline through fall to a low in December (**Figure 13**). The frequency of reported cases of rabies in cattle and dogs did not appear to have a strong seasonal pattern.

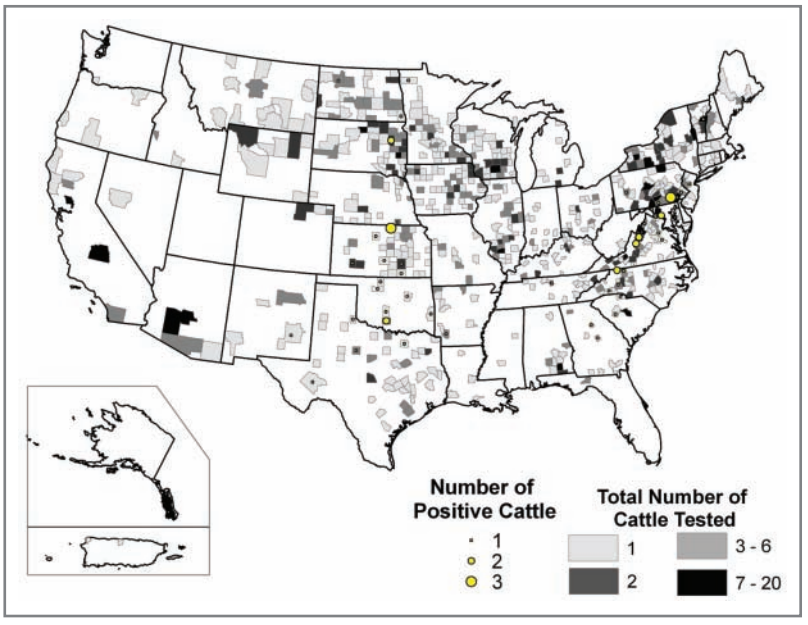

Figure 11—Reported cases of rabies in cattle, by county and municipio (Puerto Rico), 2007.

Rabies in Humans

One case of rabies in a human was reported in the United States in 2007 (**Table 2**).[34] The CDC was contacted by the Minnesota Department of Health on October 16th, 2007, regarding a suspected case of rabies in a Minnesota resident. The 46 year-old male had gone to an outpatient facility on September 19th, 2007, with paresthesia in his right hand. Over the next 3 days, the paresthesia spread to the upper extremity, and the patient's gait became unsteady. The man was hospitalized on September 29th, with fever and progressive respiratory failure, and was transferred to a tertiary care facility on October 5th because of continued progressive neurologic decline. On October 15th, rabies was considered after further analysis of the clinical symptoms and compatible brain imaging abnormalities resembling rabies encephalitis. The family was interviewed regarding potential exposures and indicated that the patient had handled a bat with his bare hands at a cabin in August. The patient had reportedly mentioned feeling a needle prick sensation before releasing the bat. On October 17th, samples were submitted to the CDC, and rabies was confirmed by identification of rabies neutralizing antibodies in serum and CSF. Rabies virus was not detected in saliva or the nuchal skin biopsy, preventing characterization of the virus involved in the exposure. Because of the poor prognosis of the patient, medical care was withdrawn on October 20th, 2007 (22nd day of hospitalization).

The number of samples being submitted to rule out rabies from encephalitic patients has increased since the Wisconsin protocol became available. However, during 2007, samples from 59 patients were submitted to the CDC for rabies diagnosis, compared with 64 during 2006. Prevention of rabies consisting of health communication to inform the public of what constitutes a rabies exposure and the application of appropriate and timely human rabies PEP remain the primary methods of preventing clinical disease and death from rabies in humans.

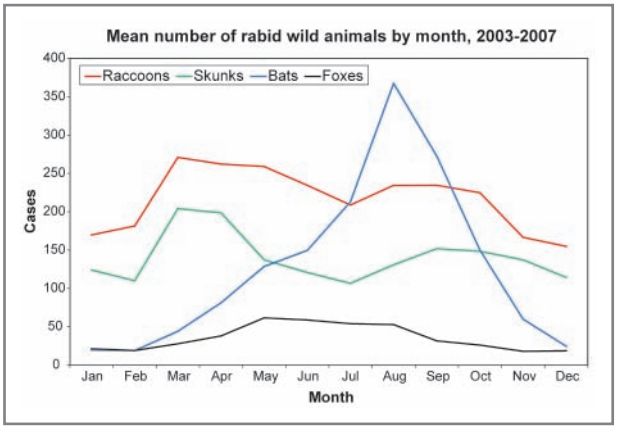

Figure 12—Mean number of cases of rabies in wild animals in the United States, by month, 2003 to 2007.

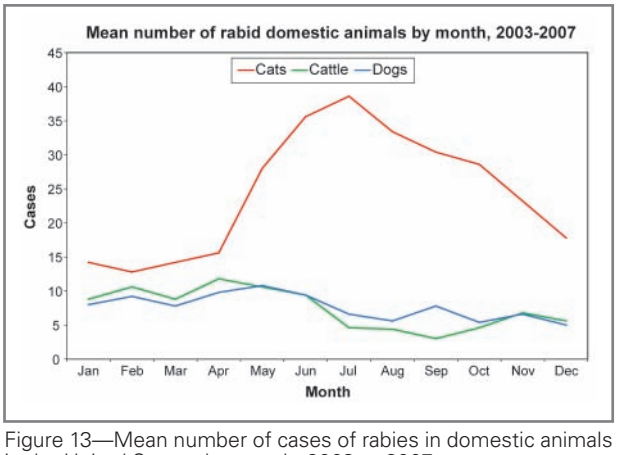

Figure 13—Mean number of cases of rabies in domestic animals in the United States, by month, 2003 to 2007.

Rabies in Canada and Mexico

Canada reported 273 laboratory-confirmed cases of rabies in domestic and wild animals in 2007. This represented an increase of 19.2% from the 229 rabies cases reported in 2006 and is the first increase since 1999 to 2000. Eighty-nine percent (n = 243) of reported cases

Table 2—Cases of rabies in humans in the United States and Puerto Rico, 2000 through 2007,* by circumstances of exposure and rabies virus variant.

Date of death	State of residence	Exposure history†	Rabies virus variant‡
20 Sep 00	CA	Unknown§	Bat, Tb
9 Oct 00	NY	Bite-Ghana	Dog, Africa
10 Oct 00	GA	Unknown§	Bat, Tb
25 Oct 00	MN	Bite	Bat, Ln/Ps
1 Nov 00	WI	Unknown§	Bat, Ln/Ps
4 Feb 01	CA	Unknown§-Philippines	Dog, Philippines
31 Mar 02	CA	Unknown§	Bat, Tb
31 Aug 02	TN	Unknown§	Bat, Ln/Ps
28 Sep 02	IA	Unknown§	Bat, Ln/Ps
10 Mar 03	VA	Unknown§	Raccoon, eastern United States
5 Jun 03	PR	Bite	Dog/mongoose, Puerto Rico
14 Sep 03	CA	Bite	Bat, Ln/Ps
15 Feb 04	FL	Bite	Dog, Haiti
3 May 04	AR	Bite (organ donor)	Bat, Tb
7 Jun 04	OK	Liver transplant recipient	Bat, Tb
9 Jun 04	TX	Kidney transplant recipient	Bat, Tb
10 Jun 04	TX	Arterial transplant recipient	Bat, Tb
21 Jun 04	TX	Kidney transplant recipient	Bat, Tb
Survived 04	WI	Bite	Bat, unknown
26 Oct 04	CA	Unknown§	Dog, El Salvador
27 Sep 05	MS	Unknown§	Bat, unknown
12 May 06	TX	Unknown§	Bat, Tb
2 Nov 06	IN	Bite	Bat, Ln/Ps
14 Dec 06	CA	Bite	Dog, Philippines
20 Oct 07	MN	Bite	Bat, unknown

*All laboratory-confirmed cases of rabies in humans who developed the disease in the United States and Puerto Rico, 2000 through 2006. †Data for exposure history are reported only when the biting animal was available and tested positive for rabies, when plausible information was reported directly by the patient (if lucid or credible), or when a reliable account of an incident consistent with rabies exposure (eg, dog bite) was reported by an independent witness (usually a family member). ‡Variants of the rabies virus associated with terrestrial animals in the United States and Puerto Rico are identified with the names of the reservoir animal (eg, dog or raccoon), followed by the name of the most definitive geographic entity (usually the country) from which the variant has been identified. Variants of the rabies virus associated with bats are identified with the names of the species of bats in which they have been found to be circulating. Because information regarding the location of the exposure and the identity of the exposing animal is almost always retrospective and much information is frequently unavailable, the location of the exposure and the identity of the animal responsible for the infection are often limited to deduction. §In some instances in which the exposure history is unknown, there may have been known or inferred interaction that, especially for bats, could have involved an unrecognized bite.

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

were in wild animals, 7.0% (19) in livestock, and 4.0% (11) in domestic pet species. Raccoon cases increased during 2007 (5 cases in 2006 to 59 cases in 2007) and accounted for 21.6% of all rabid animals in 2007. In addition, reported cases in bats increased by 29.2% (72 cases in 2006 to 93 cases in 2007). Decreases occurred mainly in skunks and domestic livestock. Reported cases in skunks decreased by 7.1% (84 cases in 2006 to 78 cases in 2007), accounting for 28.6% of all rabies. Reported cases in cattle and equids also decreased by 42.3% (26 cases in 2006 to 15 cases in 2007) and 71.4% (7 to 2), respectively. Cases in dogs and cats decreased 46.2% (13 cases in 2006 to 7 cases in 2007) and 50.0% (6 to 3), respectively, in 2007. One case of human rabies in Canada was reported in 2007. A 73-year-old man, from the province of Alberta, died in a hospital because of a rabies virus variant associated with silver-haired bats (*L noctivagans*).[35]

Mexico reported 288 cases of animal rabies in domestic and wild animals to PAHO during 2007. This represents a 2.5% increase from the number of cases (n = 281) reported to PAHO during 2006. Fourteen percent (42/288) of rabies cases were reported in dogs. Other domestic animals reported include 227 cattle (78.8% of all animals reported), 3 cats (1.0%), and 14 other livestock (4.9%). Two cases of rabies were reported in wildlife species. No cases of rabies in humans were reported to PAHO during 2007.

Discussion

The number of reported cases of rabies represents only a fraction of the total cases that occur each year. Many rabid animals are never observed and therefore go undetected and untested.[36] Cases of rabies included in this report are only those that were confirmed by laboratory diagnosis and reported to the CDC by state and territorial health departments. State health authorities have different requirements for submission of specimens for rabies diagnosis, and thus, levels of surveillance vary. The predominantly passive nature of rabies surveillance and lack of estimates of animal populations dictate that accurate incidence and prevalence data for rabies cannot be determined for most species. To better estimate regional trends, determine surveillance efforts, and identify possible biases, states are encouraged to submit denominator data (ie, data for animals tested but found test negative by DFA) by species, county, and temporal occurrence.

Passive surveillance is reliant on the interaction of humans with animal reservoirs and the subsequent possible exposure of a person to rabies. Moreover, reporting at an aggregate political boundary (ie, counties) complicates the ability to detect and analyze detailed relationships between any environmental variables and the spread of rabies. Enhanced surveillance performed by several state health departments and the USDA WS augments passive public health surveillance in critical geographic areas such as ahead of epizootic fronts. Combined with a real-time, coordinate-based surveillance system (RabID) and the use of the direct rapid immunohistochemical test[37] by USDA WS in the field, such enhanced surveillance is important in defining accurately the leading edge of the raccoon rabies virus variant reservoir as well as providing input for the various ORV programs along this front.[38]

The number of cases of raccoons with rabies reported in 2007 increased 1.7% from those reported in 2006. Although raccoons continue to account for the highest percentage (36.7%) of rabies cases reported among animals in the US in 2007, the magnitude of

this ratio has declined despite the increased number of reported cases (Figure 2). Enzootic transmission of rabies among raccoons, and from rabid raccoons to other species, continued in 20 states, New York City, and the District of Columbia in 2007. The proportion of animal rabies cases geographically associated with the raccoon rabies virus variant reflects the high public health burden of this variant, compared with other terrestrial variants in the US. Moreover, the human exposure risk to this variant is substantial, as reflected in cross-sectional studies[39,40] of human PEP.

Rabid bats continue to be identified from all US states, with the exception of Hawaii. The epizootiology and genetics of rabies in bats is distinct from terrestrial rabies maintained by mammalian carnivores. Knowledge regarding the circulation of rabies virus variants in bat species remains less developed than that regarding those found in carnivores. Although some potential exists for the control of terrestrial rabies in the United States through the use of oral vaccines, as has been accomplished in Europe[41] and southeastern Canada,[14] these control actions will have no effect on enzootic rabies in bats and the associated risk of human disease.

The occurrence of rabies in different bat species varies by geographic region. Bat-associated rabies virus variants account for the majority of human infections acquired in the United States during recent years. This trend has been highly publicized and resulted in public health recommendations for potential rabies exposures involving bats.[42,43] Increased publicity and awareness of bats and rabies have increased the rate of submission of bats for diagnostic testing because of a potential exposure. Despite the considerable increase of 27.2% in the number of bats reported from 2006 to 2007, the percentage of bats with positive results increased by less than 0.5%. However, significant regional increases in the number of reported cases were observed, notably in Illinois and Michigan. Michigan reported a 410.2% (39 to 199) increase in the number of rabid bats from last year (4.1% of bats had positive results in 2006, compared with 10.8% in 2007).

Reports of rabid skunks decreased in 2007. This continues the overall declining trend of skunks as reflected by the proportion of the total number of animals reported annually with rabies. In the southwest, Arizona reported a continued decrease in the number of rabid skunks (13) following a large increase in 2005. During 2001, a new focus of rabies in skunks, in the Flagstaff area of northern Arizona, related to a big brown bat rabies virus variant was recognized as having sustained transmission among skunks. In response to this new variant, Arizona responded with trap, vaccinate, and release programs targeted at skunks as well as a field trial with V-RG to orally vaccinate skunks. No cases of this variant were reported during 2007, and no cases have been reported since 2005.[22,44]

On the basis of antigenic typing of the virus from a subsample of rabid skunks from areas where raccoon rabies is enzootic, most rabid skunks in these states are presumed to be infected with the raccoon rabies virus variant. To date, studies[45] have been unable to find evidence of unique adaptation, circulation, or maintenance of the raccoon rabies virus variant in skunks. States where the raccoon rabies virus variant is enzootic continue to report approximately half of the total cases of rabies in skunks. As such, only about half of all reported skunks are infected with one of the skunk rabies virus variants.

Recent epizootics in Alaska, involving the arctic fox rabies virus variant, accounted for more than 45% of the increase in the total number of rabid foxes during 2007, compared with the previous year. The red fox rabies virus variant has not been detected in the northern United States in excess of 5 years, most likely because of control measures (eg, ORV) in place in Canada. Cases of rabies in foxes reported by eastern states were most likely related to the rabies virus variant associated with raccoons, as supported by samples further tested by antigenic and molecular methods. Rabies in gray foxes in Arizona and Texas are typically the result of infection with gray fox variants found in each of those states.

Throughout the western hemisphere, small mammals have never been implicated as potential reservoir species. Rabies among rodents and lagomorphs reflects spillover infection from regional terrestrial reservoir species. Among rodents, rabies occurs primarily in groundhogs (46 cases reported in 2007) in areas of the country affected by the raccoon rabies virus variant.[46] Rabies is occasionally reported in other large-bodied members of this group, such as beavers (4 cases in 2007). Large-bodied wild rodents or captive domestic species in outdoor cages or pens may become infected and survive long enough to pose a risk to other species or humans.[47] Rabies is seldom reported in smaller rodents, presumably because of the higher mortality rate and severe trauma that result from an attack by a rabid carnivore. There has been no documentation of rabies virus transmission from a rodent or lagomorph to a human.

Despite the threat of rabies transmission from wild terrestrial carnivores, the use of population-reduction programs to control rabies among such animals is not desirable. Programs to control rabies in Europe and southeastern Canada have used modified-live or recombinant virus vaccines for the oral immunization of free-ranging wildlife reservoir species (predominantly foxes). The use of ORV in Switzerland during the past 30 years resulted in a declaration of rabies-free status for that country in 1998, and similar strategies in France led to rabies-free status being declared in 2000.[48] The elimination of a rabies virus variant associated with red foxes in southern Ontario also supports the hypothesis that rabies virus variants associated with foxes can be eliminated by oral vaccination.[14]

Oral vaccination programs may have restricted the expansion of raccoon rabies. The vaccine was conditionally licensed in April 1995 and was fully licensed in April 1997. Vaccine distribution in each state remains limited to authorized state or federal rabies control programs. Interventions using the V-RG vaccine distributed within baits to vaccinate wild raccoons to prevent or slow the geographic expansion of rabies continue in a number of states and are being expanded. The effectiveness of these programs remains under assessment in multiple states, including Alabama, Florida (Pinellas County), Georgia, Maine, eastern Massachusetts (Cape

Cod),[19] New Hampshire, southern New Jersey (Cape May),[18] New York, North Carolina, Ohio, Pennsylvania, Tennessee, Vermont, Virginia, and West Virginia.

During 2007, multiple state agencies, the USDA WS, and the CDC continued partnerships and cooperation in a massive undertaking to maintain and expand an "immune barrier" beginning on the shores in Ohio, Pennsylvania, and New York and intended to reach the Gulf of Mexico in Alabama, in an attempt to curtail the spread of raccoon rabies. In Ohio, Pennsylvania, Maryland, West Virginia, Virginia, North Carolina, and northeast Tennessee (otherwise known as the Appalachian Ridge ORV zone), approximately 4 million doses of V-RG vaccine–laden baits were distributed. In addition, approximately 1 million doses of oral vaccine were distributed again in Georgia, Alabama, and Tennessee (otherwise known as the GAT ORV zone).[49] Enhanced surveillance conducted by the USDA WS and routine surveillance by state public health agencies continue to determine the placement of new ORV zones as well as the shape of baiting zones each year.[50] This barrier will be extended farther south and moved eastward over time in an attempt to contain and reduce the area of enzootic rabies in raccoons.[50,51] Concerns regarding vaccine safety, efficacy, ecologic impact, and physical bait variables, which were raised during earlier trials, continue to be assessed.[20,21,50–54] Novel biologics are also being developed as potential candidates for new vaccines to overcome the limited efficacy of the V-RG vaccine in certain animal species (eg, skunks and mongooses).[55–58]

Control efforts consisting of ORV (approx 3.4 million baits)[49] continued in Texas in an attempt to contain and eliminate the gray fox rabies virus variant and prevent the reintroduction of canine rabies virus variants associated with coyotes and dogs from Mexico during 2007.[10–12] Past translocation of animals infected with canine rabies virus variants found in Texas has been documented.[6,7] These events involved infected animals placed in outdoor enclosures used for commercialized hunting venues. Rapid responses to these previous events may have prevented local establishment and spread of these variants.

Rabies in domestic animals decreased 11.9% in 2007. Despite the overall decline in reported cases of rabies in domestic animals, a 17.2% increase in the reported cases of rabies in dogs occurred during this period. Cases of rabies in cats and dogs are primarily attributable to spillover from local terrestrial reservoirs.[59] The United States has been free of dog-to-dog transmission of rabies since 2004.[8,32] However, continued surveillance will be required for early detection and to prevent this rabies virus variant or others from being reintroduced to the United States. During 2007, this continued surveillance was tested when a puppy, which had been recently imported from India, was found positive for rabies in Alaska.[33] In addition, ongoing collaboration with Mexico via the Border Infectious Disease Surveillance project is targeted at monitoring for the dog/coyote rabies virus variant along the border and continuing vaccination programs into Mexico for the ultimate eradication of this variant.

The number of cases of rabies reported for cats was roughly 3 times the number reported for dogs and nearly 5 times the number reported for cattle. Since 1992, cats have remained the leading domestic animal reported each year.[60] In addition, a study[39] indicates cats are a leading domestic animal source of possible human exposure to rabies requiring PEP. In 2007, a stray, rabid kitten that had been handled by players on approximately 60 teams at a softball tournament in South Carolina resulted in a massive multistate public health investigation in which 27 persons received PEP.[61] Further reduction in the number of rabies cases in companion species, especially cats, may require stricter observance and enforcement of vaccination and leash laws. Vaccination remains a crucial element in this effort.

Rabies vaccination of pet mammals and livestock that have regular contact with people is a fundamental barrier to human exposure. A single incident involving a case of rabies in a companion animal species can result in large economic expenditures and public health efforts to ensure that human disease does not occur.[62–64] 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 (ie, in a petting zoo) in rabies epizootic areas should be considered.[42]

Thirty cases of human rabies have been reported in the United States since 1997, including the 1 case reported in 2007. Six (20.0%) of these 30 individuals were infected outside the continental United States (5 abroad and 1 in Puerto Rico). The majority of human rabies infections that occur in foreign countries where rabies is enzootic in dogs involve regional canine rabies virus variants. A bite from a dog was reported in 3 of 5 such cases and the case from Puerto Rico (4/6). Twenty-four (80.0%) of the 30 individuals were infected with rabies virus variants indigenous to the United States. Analysis of monoclonal antibodies and genetic sequencing data indicated that 20 (83.3%) of these 24 persons were infected with bat rabies virus variants. Three additional cases implicated a bat as the most likely source of exposure after epidemiologic investigations. Since 1997, only 6 of the human cases of rabies reported a definite bat bite (4 received organ transplants or an arterial graft from a rabies virus–infected donor).[6,25] Four cases of bat-associated rabies were reported to have no known exposure to a bat. The remaining 10 cases indicated some prior contact with a bat (eg, awaking to find a bat on the body or picking up a grounded bat). The most likely route of infection with rabies virus (excluding inoculation via infected transplant material) remains transmission by a bite that either was ignored or went unnoticed during an interaction with a bat. Although rabies infection of humans from bats remains a rare occurrence, the prevention of such infections remains an important public health concern.

Rabies should be included in the differential diagnosis of any unexplained acute, rapidly progressive encephalitis, especially in the presence of autonomic instability, dysphagia, hydrophobia, paresis, or paresthesia.[65] Since the survival of a rabies patient after an experimental treatment in 2004, early diagnosis of potential rabies cases has become increasingly important if experimental treatment is to be considered.[66] However, the benefits from any particular experimental rabies treatment regimen have not been determined. No single

course of treatment for rabies in humans has been efficacious after clinical signs of rabies are evident.

2008 Rabies Update

A brief analysis of data from states submitting monthly data to CDC for the first 4 months of 2008 revealed a decline in the number of cases of rabies, compared with the same period and states from 2007. One case of human rabies was reported from California during the first 5 months of 2008. In March 2008, a newly arrived immigrant from Mexico went to a hospital in Santa Barbara, Calif, with encephalitic symptoms and died shortly thereafter. Rabies was suspected on the basis of symptoms and reports of domestic and wildlife animal exposures received in Oaxaca, Mexico. At autopsy, samples were submitted for rabies testing and found to be infected by DFA by the California Department of Health Services. Further confirmation and characterization by the CDC identified a novel rabies virus variant, most closely related to rabies virus variants associated with free-tailed bats upon phylogenetic analysis. An updated version of the Advisory Committee on Immunization Practices recommendations on human rabies prevention was released in May 2008, in addition to the annual update of the rabies compendium.[67,68] These updated recommendations provide an evidence-based approach to current recommendations for rabies preexposure vaccination and PEP. In addition, updated information on available biologics is provided as well as a more thorough discussion of the recommendations regarding cryptic exposures involving bats.

Ongoing rabies vaccine supply issues reinforce the need to emphasize basic human rabies prevention and prophylaxis recommendations. Starting in June 2007, the makers of IMOVAX rabies vaccine began renovating their production facility in France to maintain compliance with the most current requirements from the FDA and French regulatory bodies. Prior to this, they had established an inventory of vaccine based on historical usage and projected demand. Concomitantly, the makers of RabAvert rabies vaccine, the other supplier of rabies vaccine in the United States, were unable to meet projected supplies. As of May 2008, all pre-exposure rabies vaccination has been suspended in the United States, except for critical need as determined by consultation and approval through state and federal public health officials. Because of higher than expected usage rates of rabies vaccine for postexposure prophylaxis, supplies continue to be closely monitored. Judicious and appropriate use of rabies vaccines is crucial to averting a situation in which persons exposed to rabies are put at increased risk because of an exhausted vaccine supply. Supplies are projected to improve in late 2008 to early 2009. Physicians are encouraged to consult with local and state health authorities regarding current recommendations before administering rabies biologics.

Following the considerable success of the first World Rabies Day, celebrated on September 8th, 2007, additional activities are planned for the second annual World Rabies Day on September 28th, 2008. World Rabies Day seeks to raise awareness about human and animal rabies, its prevention, and the goal of eliminating rabies from major worldwide reservoirs.[69] During the first World Rabies Day, activities took place in 74 countries, with approximately 86,000 participants involved in special events and an estimated 51.4 million people reached through promotional messages distributed by television, by radio, and in print.[70]

a. ArcMap, version 9.1, ESRI, Redlands, Calif.

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