

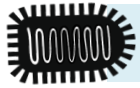
Rabies Surveillance in California

Annual Report 2021

Veterinary Public Health Section
Infectious Diseases Branch
Division of Communicable Disease Control
Center for Infectious Diseases
California Department of Public Health

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Introduction

Rabies is a severe zoonotic encephalitis caused by a Rhabdovirus of the genus *Lyssavirus*. Following an incubation period that can range from a few days to several years, early clinical signs and symptoms of rabies—including headache, fever, chills, cough or sore throat, anorexia, nausea, vomiting, and malaise—are non-specific and can be mistaken for more common conditions. Symptoms progress rapidly (within 1-2 weeks) to central and peripheral neurologic manifestations including irritation at the site where the virus was introduced, altered mental status (e.g., hyperactivity and agitation), hydrophobia, excessive salivation, and difficulty swallowing due to laryngeal spasms. Ultimately, autonomic instability, coma, and death occur, due mainly to cardiac or respiratory failure. No treatment protocol has proven consistently effective for clinical rabies and reports of patients surviving are exceedingly rare. If a person is exposed to the virus, prompt post-exposure prophylaxis (PEP) by administration of rabies immune globulin and vaccine can prevent progression to clinical rabies.

Rabies virus variants (RVV) are maintained in certain mammalian species, but all rabies viruses are capable of infecting any mammal, including humans. In California, bat RVVs exist throughout the state, while the California skunk RVV is found mostly north of the Tehachapi mountain range. Domestic animals (dogs, cats, and livestock) can be infected with these RVVs through contact with rabid wildlife; but the rarity of domestic animal rabies in California limits the potential for the virus to evolve and sustain transmission in these species. Each year since 1957, the Director of the California Department of Public Health (CDPH) has identified counties in California where rabies constitutes a public health hazard. The Director has declared all 58 counties in California as rabies areas every year since 1987.

Since the early 20th century, CDPH has overseen a statewide rabies surveillance and control program. Local departments of public health and environmental health, animal control agencies and shelters, and medical and veterinary practitioners collaborate with CDPH to prevent rabies in California by:

- Providing reliable laboratory services for the diagnosis of rabies in humans and animals,
- Regulating and enforcing rabies vaccination of dogs to provide a protective “firewall” that reduces the potential for human exposure,
- Investigating reports of animals that bite humans,
- Evaluating animals for rabies by confinement and observation for a specified period, or by euthanasia and testing,
- Offering recommendations for PEP to persons following a known or suspected exposure to rabies,
- Developing and disseminating preventive education on rabies, and
- Collecting, collating, and reporting surveillance data on rabies in humans and animals.



Reporting and Analysis

The California Code of Regulations (17 CCR §2500) lists rabies that is diagnosed in either humans or animals as a reportable disease. Health care providers, including physicians and veterinarians, having knowledge of a confirmed or suspected case of rabies are required to report this knowledge immediately to the local health officer. Diagnostic testing of human patients who have signs and symptoms suggestive of rabies is challenging, and no single test can accurately diagnose rabies ante-mortem. Therefore, several tests on multiple tissue samples are typically pursued. Diagnosis can be made by detection of virus antigen in nuchal skin biopsy, brain biopsy, or saliva by direct fluorescent antibody assay (DFA) or polymerase chain reaction; or by demonstration of rabies-specific antibodies in blood or cerebrospinal fluid of previously unvaccinated patients by immunofluorescent antibody assay or Rapid Fluorescent Focus Inhibition Test (RFFIT). Infection with rabies is confirmed post-mortem in humans and animals by detection of rabies virus antigen, typically in central nervous system tissue, by DFA performed by a certified public health microbiologist. The CDPH Viral and Rickettsial Diseases Laboratory (VRDL) provides primary and confirmatory testing for rabies in animals, diagnostic testing of human patients suspected to have rabies, and characterization of rabies viruses to RVV type. Local public health departments report confirmed cases of rabies in humans and animals to CDPH. This surveillance report summarizes information on confirmed cases of rabies in humans and animals reported to CDPH in 2021.

In 2021, 30 local public health laboratories in California employed trained microbiologists and maintained resources to perform rabies testing in animals.

Rabies in Animals

In 2021, specimens from 4,503 animals were tested for rabies in California – approximately 18 percent fewer than the annual average of 5,476 specimens tested during the previous ten years, 2011-2020. Of the 56 counties that submitted at least one animal for rabies testing, the number of animals tested per county ranged from 1 to 690.

Rabies was confirmed in 220 animals, 11 percent fewer than the 248 cases confirmed in 2020 and 5 percent below the annual average of 231 cases in 2011-2020 ([Table A](#)). One or more rabid animals were identified in 39 counties, which reported between 1 and 68 rabid animals each.

Wild Animals

Rabies was diagnosed in 220 wild animals in 2021, accounting for 100 percent of all rabid animals reported to CDPH. Bats (187, 85%) were the wild animal most frequently reported rabid, followed by skunks (29, 13.2%), and foxes (4, 1.8%).

Bats

A total of 1,749 bats from 54 counties were tested for rabies in 2021 ([Figure A](#)).

Rabies Surveillance in California – Annual Report, 2021

The 187 rabid bats reported in 2021 were 7 percent lower than the annual average of 201 reported in the preceding ten years, 2011-2020 ([Figure B](#)). The greatest number of rabid bats (68) was reported in Los Angeles County, which reported the most rabid bats in each of the past ten years ([Table A](#), [Figure C](#)). The six southern California counties of Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Ventura collectively accounted for 110 (59%) of all rabid bats detected in California in 2021. Rabid bats were most frequently reported during the late spring and early autumn months; roughly three fourths (134, 72%) of all rabid bats were reported in the five months of May through September ([Figure D](#)). Species were identified for 155 rabid bats: 68 western pipistrelle (*Parastrellus hesperus*), 48 Mexican free-tailed bats (*Tadarida brasiliensis*), 11 California myotis (*Myotis californicus*), 9 Yuma myotis (*Myotis yumanensis*), 9 big brown bats (*Eptesicus fuscus*), 5 Hoary bats (*Lasiurus cinereus*), 2 Western yellow bats (*Lasiurus xanthinus*), 2 long-eared myotis bats (*Myotis evotis*), and 1 little brown bat (*Myotis lucifugus*).

Skunks

A total of 250 skunks (*Mephitis mephitis*) from 32 counties were tested for rabies in 2021, of which 29 from 8 counties were confirmed rabid ([Figure A](#), [B](#)). The 29 rabid skunks in 2021 was slightly greater than the annual average of 25 in the preceding ten years, 2011-2020. The greatest numbers of rabid skunks were reported in El Dorado (9) and Sacramento (9) counties.

Foxes

A total of 50 foxes from 20 counties were tested for rabies in 2021. The four confirmed rabid foxes in 2021 were similar to the annual average of three foxes reported in the previous 10 years, 2011-2020 ([Figure B](#)). Rabies virus from the rabid fox in Sierra County was identified as Yuma myotis bat variant, and viruses from the three rabid foxes in Plumas County as two California myotis and one Mexican free-tailed bat variants.

Domestic Animals

In 2021, 2,022 domestic animals (dogs, cats, horses, cattle, goats, sheep, and swine) were tested for rabies. Rabies was not confirmed in any domestic animals in California in 2021.

Rabies in Humans

Rabies was not diagnosed in any California resident in 2021. Two cases of rabies were diagnosed in California residents in the previous ten years (2011-2020): Humboldt County in 2011 and Contra Costa County in 2012.

Rabies in the United States

At the time of this report, United States rabies surveillance data for 2021 has not been published.



Discussion

Over the last 20 years, bats have accounted for 62 to 95 percent of all rabid animals identified in California. In the United States, bat RVVs are the predominant cause of human rabies. Of the 38 U.S. cases of human rabies between 2000 and 2020 that could be attributed to indigenous transmission (case-patient had no history of travel outside the U.S. during the incubation period), exposure to bats or bat RVVs was responsible for 31 (86%) —including California's most recent human rabies case in 2012 [Ma 2021].

Bats were the most frequently reported rabid animal in California in 2021, as they have been each year since 2000.

Skunks continued to be the second most frequently reported rabid mammal in California. A unique RVV circulates in California skunks in historically recognized enzootic regions. The principal concentration of skunk rabies in California is along the western Sierra Nevada foothills from Madera County northward to Placer County. These seven counties, plus neighboring Sacramento and San Joaquin counties, accounted for 27 (79%) of 29 rabid skunks in 2021, and 230 (87%) of 263 rabid skunks detected in the last ten years (2012-2021). Sporadic cases of skunk rabies are also occasionally identified in the coastal counties of Monterey and Santa Barbara. In 2020, over 800 rabid skunks were reported nationwide—second only to raccoons as the most commonly identified terrestrial mammal with rabies [Ma 2021]. In addition to the California RVV, two virus variants adapted to maintenance in skunks are enzootic in Northern Central and Southern Central states. Skunks are also often infected with spillover RVVs including the Atlantic raccoon, Arizona fox, and various bat species variants. The opportunistic susceptibility of skunks to encounter multiple different potentially rabid animals across the continent, combined with their predisposition to reside in peri-residential areas, render skunks particular concerning for transmission of rabies to humans and pets. Because of this enhanced rabies risk, California public health regulations (California Code of Regulations, Title 17, Section 2606.8) specifically prohibit the capture, holding, transport, or sale/transfer of skunks.

Rabies was detected in four foxes in 2021. While this number is comparable to recent years (2000-2020), in which zero to six rabid foxes were typically identified in California, the rabid foxes in Plumas County were the first in that county since 1970 and the fox in neighboring Sierra County the first rabid animal of any species in that county since 1990. Two of the rabid foxes in Plumas County were concerning because they were collected within two days and 5 km of one another. (These two foxes were separated from the other Plumas County rabid fox by approximately five weeks and 27 km, and from the Sierra County fox by 11 weeks and 35 km.) Rabies in California foxes chiefly represents sporadic cross-species transmission of skunk and bat RVVs; these spillover events are unlikely to lead to secondary transmission to other members of the non-reservoir species. The two proximal rabid foxes in Plumas County were infected with differing bat RVV (California myotis, Mexican free-tailed bat), verifying that these cases were independent spillover events. While the molecular evidence

Rabies Surveillance in California – Annual Report, 2021

did not suggest a rabies outbreak among these foxes, nonetheless as the incidence of isolated spillover infections increases, there is proportionately greater potential for rabies virus to undergo mutations that facilitate sustained transmission within non-reservoir species (“host shift”). These kinds of host shifts have been previously observed with bat RVVs to raccoons and skunks [Troupin 2016]. Given the low sensitivity of conventional passive rabies surveillance, evolving rabies host shifts may remain undetected until outbreaks occur of sufficient scope to yield indicative data. A novel RVV was detected in two New Mexico foxes in the midst of numerous instances of cross-species transmission of established South Central skunk, Arizona fox, and several bat variants [Condori 2022]. This unique RVV, which was believed to be a transitional variant from migratory tree bats (genera *Lasiurus* and *Lasionycteris*), was discovered only because both foxes were thoroughly investigated as a result of independent human bite exposures. In 2009, an outbreak of rabies was identified in 38 foxes in Humboldt County. Molecular analysis identified mutational changes in the virus throughout the outbreak, but those changes were seen in both skunks and foxes, thus reflecting changes that accumulated jointly over time. There were no changes seen only in foxes, nor evidence of sustained transmission within fox populations in subsequent years, that might suggest that the virus adapted to a new host species.

No domestic animals in California were identified as rabid in 2021.

Rabies in domestic animals is rare in California with zero to six reported each of the last 10 years (2011-2020). All rabid domestic animals represented spillover of terrestrial (skunk) or volar (bat) virus from wildlife species. The domestic canine RVV was declared eliminated from the United States in 2007. When rabies is detected in a domestic animal, particularly a dog, a thorough investigation by public health officials is essential to confirm that the case does not represent a possible reintroduction of canine RVV.

Between 2015 and 2019, three dogs with rabies were imported into the United States from Egypt, a country where the canine RVV is endemic. In response, in 2019, the CDC suspended importation of all dogs from Egypt ([84 FR 20628](#)). In 2021, CDC implemented additional restrictions on dogs entering the United States from all “high-risk” countries where the canine RVV remains active ([86 FR 32041](#)). In June 2021, a confirmed rabid dog was imported into the United States from Azerbaijan, one of CDC’s designated “high risk” countries. The dog was included in a shipment of 33 other dogs (and one cat) destined for nine states, including one dog shipped to California. State and local public health officials tracked all imported dogs and tested them for serologic evidence of rabies vaccination. Approximately a quarter of dogs in the shipment showed inadequate serum antibody titers to rabies, despite all dogs having valid rabies vaccination certificates [Whitehill, et al 2022]. This was the first known case since 2007 of importation of a rabid dog due to demonstrated vaccination failure, rather than fraudulent paperwork. In June 2022, CDC extended until 2023 the temporary suspension on importation of dogs from high-risk countries ([87 FR 33185](#)), while Canada implemented an outright ban on importation of dogs from 100 countries ([Government of Canada – Notice to Industry, June 28, 2022](#)). Federal, state, and local

public health officials need to maintain continued vigilance to prevent reintroduction of canine RVV and to confront the many challenges of regulating importation of dogs from other countries.



References

Condori RE, Aragon A, Breckenridge M, et al. [Divergent rabies virus variant of probable bat origin in 2 gray foxes, New Mexico, USA.](#) *Emerg Infect Dis* 2022; 28(6):1137-1145.

Ma X, Bonaparte S, Toro M, et al. [Rabies surveillance in the United States during 2020.](#) *J Am Vet Med Assoc* 2021; 260:1157-1165. <https://doi.org/10.2460/javma.22.03.0112>

Troupin C, Dacheux L, Tanguy M, et al. [Large-scale phylogenomic analysis reveals the complex evolutionary history of rabies virus in multiple carnivore hosts.](#) *PLoS Pathog* 2016; 12(12):e1006041.

Whitehill F, Bonaparte S, Hartloge C, et al. [Rabies in a dog imported from Azerbaijan – Pennsylvania, 2021.](#) *MMWR Morb Mortal Wkly Rep* 2022; 71(20):686-689.

Rabies Surveillance in California – Annual Report, 2021

Table A. [Reported cases of rabies in animals, California, 2021.](#)

COUNTY	BAT	SKUNK	CAT	DOG	COYOTE	FOX	HORSE	SHEEP	CATTLE	RACCOON	TOTAL
TOTAL	187	29	0	0	0	4	0	0	0	0	220
Alameda	4	0	0	0	0	0	0	0	0	0	4
-Berkeley City	0	0	0	0	0	0	0	0	0	0	0
Alpine	0	0	0	0	0	0	0	0	0	0	0
Amador	3	2	0	0	0	0	0	0	0	0	5
Butte	3	1	0	0	0	0	0	0	0	0	4
Calaveras	0	2	0	0	0	0	0	0	0	0	2
Colusa	0	0	0	0	0	0	0	0	0	0	0
Contra Costa	1	0	0	0	0	0	0	0	0	0	1
Del Norte	0	0	0	0	0	0	0	0	0	0	0
El Dorado	3	9	0	0	0	0	0	0	0	0	12
Fresno	1	0	0	0	0	0	0	0	0	0	1
Glenn	2	0	0	0	0	0	0	0	0	0	2
Humboldt	0	0	0	0	0	0	0	0	0	0	0
Imperial	0	0	0	0	0	0	0	0	0	0	0
Inyo	0	0	0	0	0	0	0	0	0	0	0
Kern	1	0	0	0	0	0	0	0	0	0	1
Kings	1	0	0	0	0	0	0	0	0	0	1
Lake	0	0	0	0	0	0	0	0	0	0	0
Lassen	0	0	0	0	0	0	0	0	0	0	0
Los Angeles	68	0	0	0	0	0	0	0	0	0	68
-Long Beach City	0	0	0	0	0	0	0	0	0	0	0
-Pasadena City	0	0	0	0	0	0	0	0	0	0	0
Madera	0	0	0	0	0	0	0	0	0	0	0
Marin	6	0	0	0	0	0	0	0	0	0	6
Mariposa	0	1	0	0	0	0	0	0	0	0	1
Mendocino	0	0	0	0	0	0	0	0	0	0	0
Merced	1	0	0	0	0	0	0	0	0	0	1
Modoc	0	0	0	0	0	0	0	0	0	0	0
Mono	1	0	0	0	0	0	0	0	0	0	1
Monterey	0	0	0	0	0	0	0	0	0	0	0
Napa	2	0	0	0	0	0	0	0	0	0	2
Nevada	1	1	0	0	0	0	0	0	0	0	2
Orange	17	0	0	0	0	0	0	0	0	0	17
Placer	5	0	0	0	0	0	0	0	0	0	5
Plumas	0	0	0	0	0	3	0	0	0	0	3
Riverside	6	0	0	0	0	0	0	0	0	0	6
Sacramento	3	9	0	0	0	0	0	0	0	0	12

Rabies Surveillance in California – Annual Report, 2021

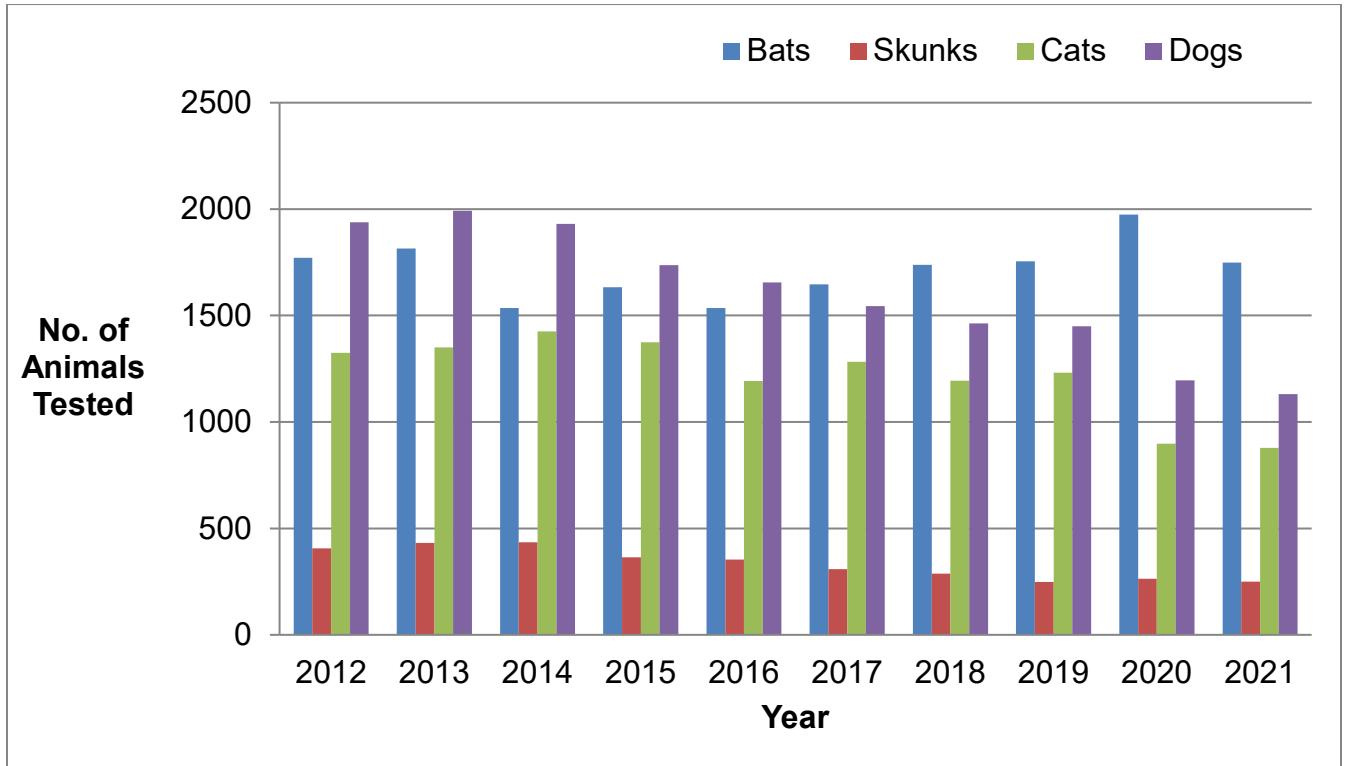
Table A (continued). [Reported cases of rabies in animals, California, 2021.](#)

COUNTY	BAT	SKUNK	CAT	DOG	COYOTE	FOX	HORSE	SHEEP	CATTLE	RACCOON	TOTAL
San Benito	0	0	0	0	0	0	0	0	0	0	0
San Bernardino	12	0	0	0	0	0	0	0	0	0	12
San Diego	4	0	0	0	0	0	0	0	0	0	4
San Francisco	1	0	0	0	0	0	0	0	0	0	1
San Joaquin	1	4	0	0	0	0	0	0	0	0	5
San Luis Obispo	2	0	0	0	0	0	0	0	0	0	2
San Mateo	4	0	0	0	0	0	0	0	0	0	4
Santa Barbara	3	0	0	0	0	0	0	0	0	0	3
Santa Clara	5	0	0	0	0	0	0	0	0	0	5
Santa Cruz	1	0	0	0	0	0	0	0	0	0	1
Shasta	0	0	0	0	0	0	0	0	0	0	0
Sierra	0	0	0	0	0	1	0	0	0	0	1
Siskiyou	0	0	0	0	0	0	0	0	0	0	0
Solano	0	0	0	0	0	0	0	0	0	0	0
Sonoma	4	0	0	0	0	0	0	0	0	0	4
Stanislaus	1	0	0	0	0	0	0	0	0	0	1
Sutter	0	0	0	0	0	0	0	0	0	0	0
Tehama	0	0	0	0	0	0	0	0	0	0	0
Trinity	0	0	0	0	0	0	0	0	0	0	0
Tulare	3	0	0	0	0	0	0	0	0	0	3
Tuolumne	1	0	0	0	0	0	0	0	0	0	1
Ventura	3	0	0	0	0	0	0	0	0	0	3
Yolo	10	0	0	0	0	0	0	0	0	0	10
Yuba	3	0	0	0	0	0	0	0	0	0	3

Source: California Department of Public Health, Veterinary Public Health Section

Rabies Surveillance in California – Annual Report, 2021

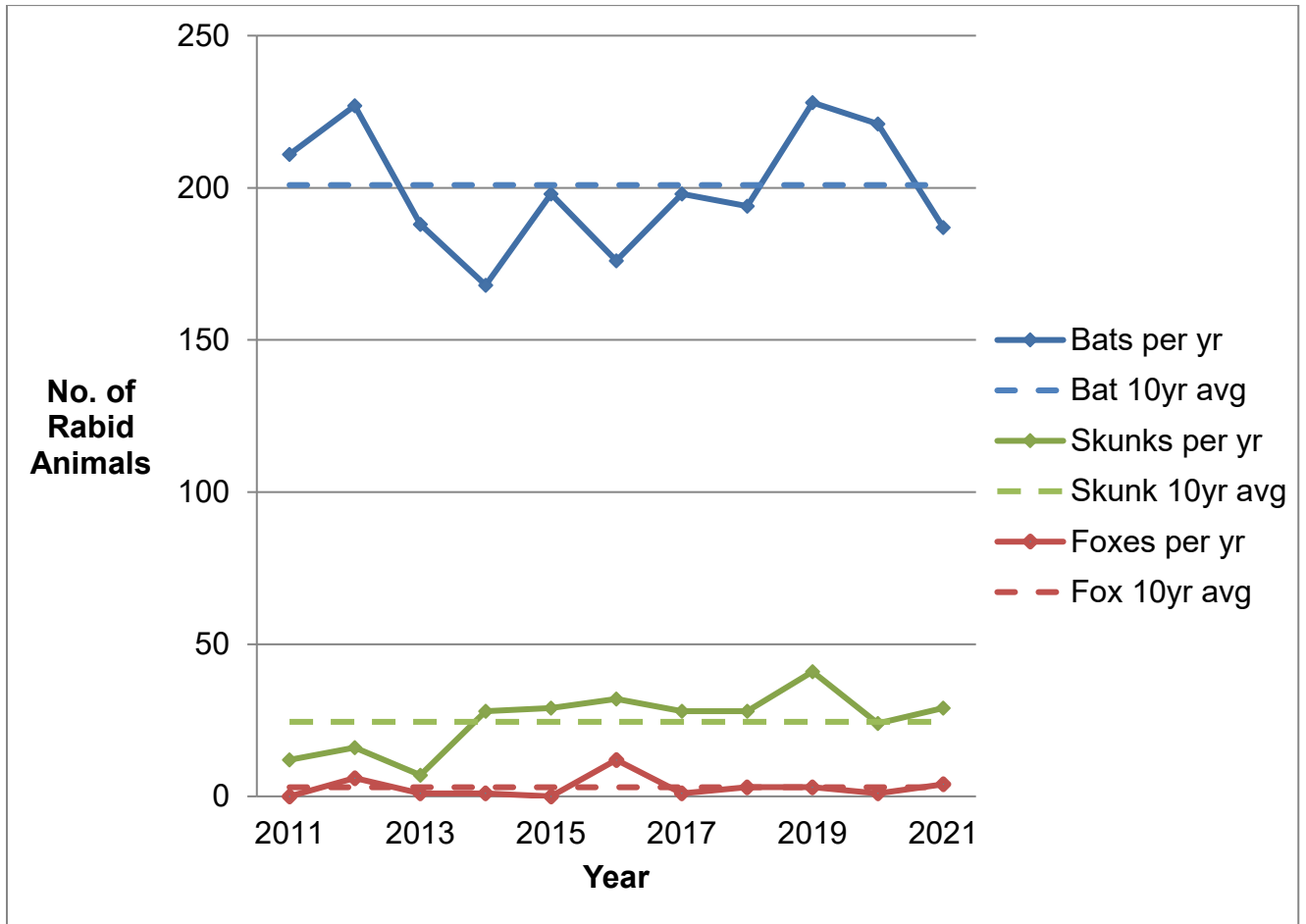
Figure A. Selected wild and domestic animals tested for rabies in California, 2012- 2021.



Source: California Department of Public Health, Veterinary Public Health Section

Rabies Surveillance in California – Annual Report, 2021

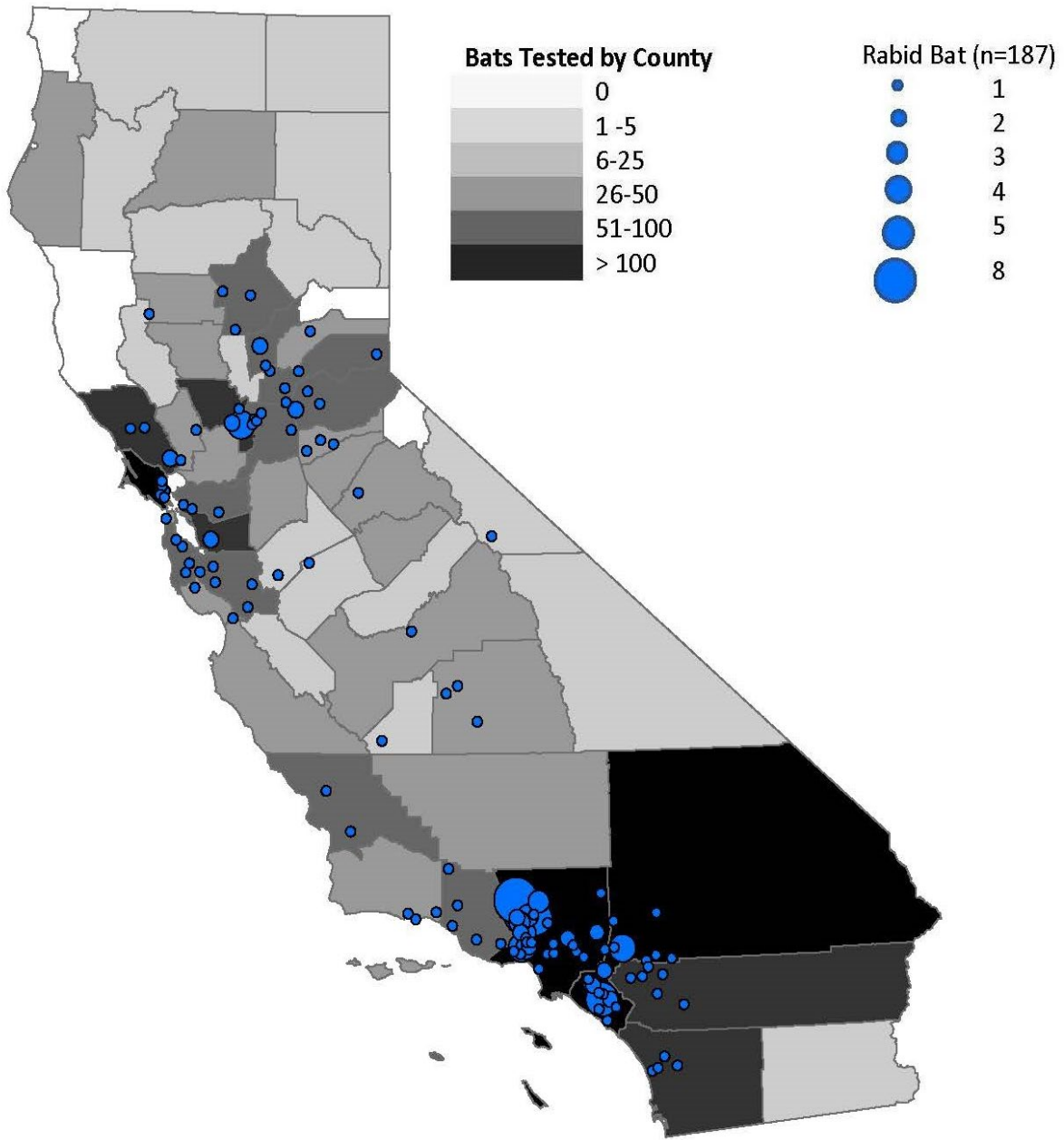
Figure B. Cases of rabies in wild animals in California, 2011-2021. (Ten-year averages represent 2011-2020 data.)



Source: California Department of Public Health, Veterinary Public Health Section

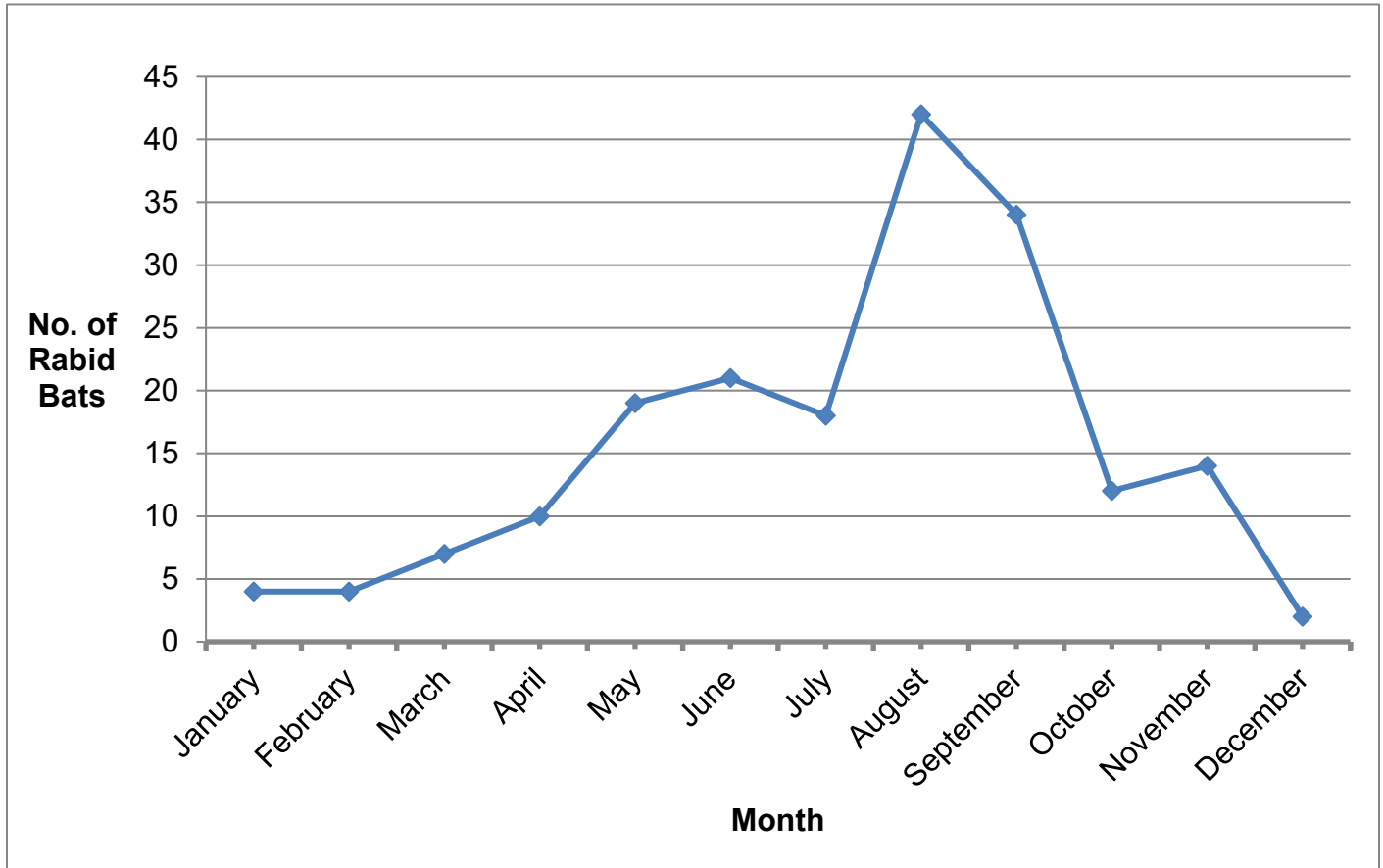
Rabies Surveillance in California – Annual Report, 2021

Figure C. Bats tested for rabies by county with positive cases by zip code of collection site, California, 2021.



Source: California Department of Public Health, Veterinary Public Health Section

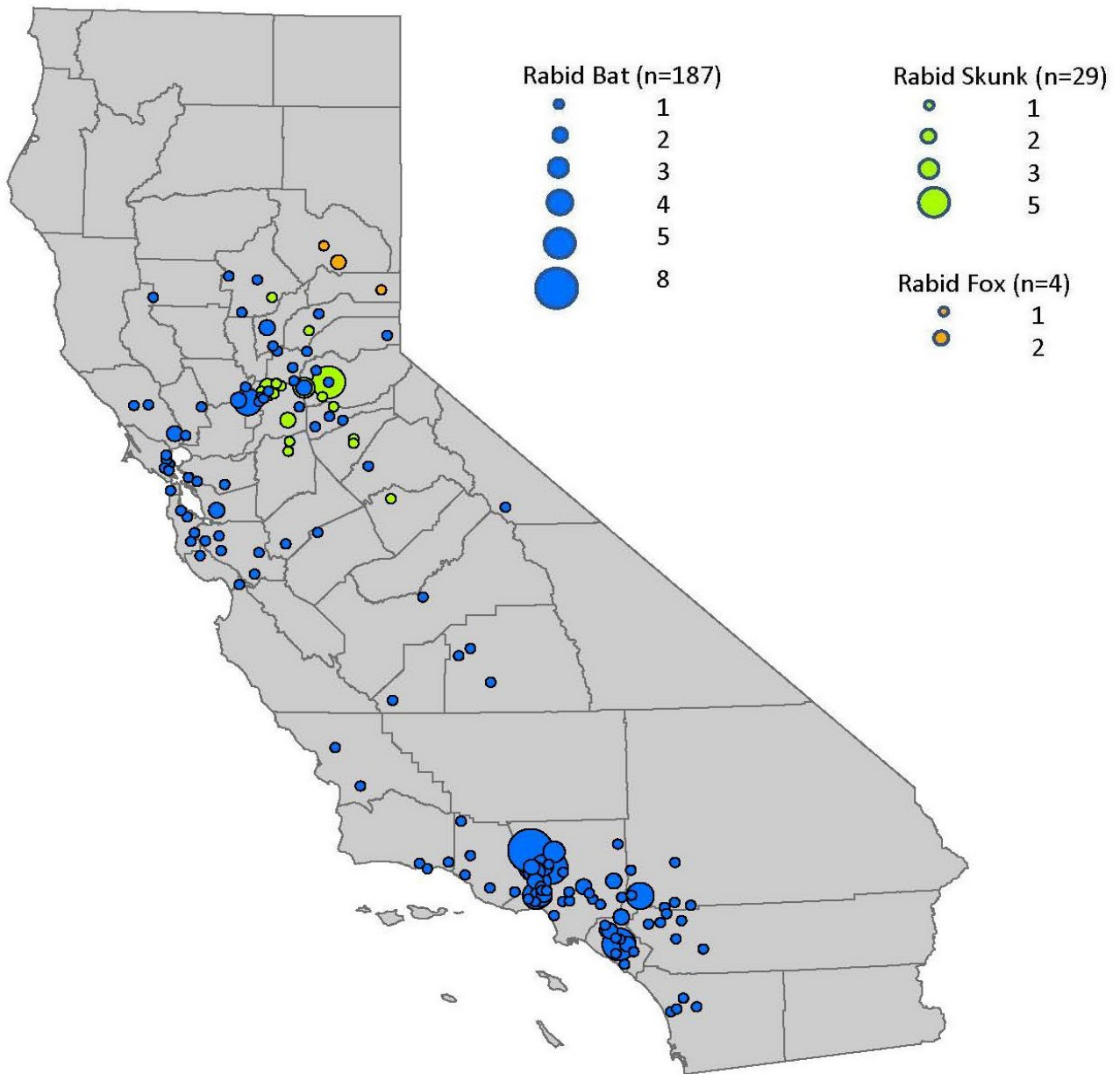
Figure D. Cases of rabies in bats by month of testing, California, 2021.



Source: California Department of Public Health, Veterinary Public Health Section

Rabies Surveillance in California – Annual Report, 2021

Figure E. Reported cases of rabies in wild animals by zip code of collection site, California, 2021.



Source: California Department of Public Health, Veterinary Public Health Section