

Rabies Surveillance in California

Annual Report 2018

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 (eg, 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 with 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 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. In 2018, 30 local public health laboratories in California employed trained microbiologists and maintained resources to perform rabies testing in animals. 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 variant 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 2018.

Rabies in Animals

In 2018, specimens from 5,084 animals were tested for rabies in California – approximately 15 percent fewer than the annual average of 5,954 specimens tested during the previous ten years, 2008-2017. Of the 54 counties that submitted at least one animal for rabies testing, the number of animals tested per county ranged from 1 to 543.

Rabies was confirmed in 226 animals, similar to the 231 cases confirmed in 2017 and slightly above the annual average of 214 cases in 2008-2017 (Table A). One or more rabid animals were identified in 40 counties, which reported between 1 and 27 rabid animals each.

Wild Animals

Rabies was diagnosed in 226 wild animals in 2018, accounting for 100 percent of all rabid animals reported to CDPH. Bats (194, 85.8%) were the wild animal most frequently reported rabid, followed by skunks (28, 12.4%), foxes (3, 1.3%), and a raccoon (1, 0.4%).

Bats

A total of 1,738 bats from 54 counties were tested for rabies in 2018 (Figure A). The 194 rabid bats reported in 2018 is higher than the annual average of 179 reported in the previous ten years, 2008-2017 (Figure B). The greatest number of rabid bats (27) was reported in Los Angeles County, which reported the most rabid bats in eight 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 35 percent of all rabid bats detected in California in 2018. Rabid bats were most frequently reported during the summer and early autumn months; roughly two thirds (131, 68%) of all rabid bats were reported in the five months from June through October (Figure D). Species was identified for 134 rabid bats: 73 Brazilian free-tailed bats (*Tadarida brasiliensis*), 22 western pipistrelle (*Parastrellus hesperus*), 13 Hoary bats (*Lasiurus cinereus*), 11 Yuma myotis (*Myotis yumanensis*), 8 big brown bats (*Eptesicus fuscus*), 3 Western yellow bats (*Lasiurus xanthinus*), 2 California myotis (*Myotis californicus*), 1 Pallid bat (*Antrozous pallidus*), and 1 Townsend's big-eared bat (*Corynorhinus townsendii*).

Skunks

A total of 288 skunks (*Mephitis mephitis*) from 34 counties were tested for rabies in 2018, of which 28 from 7 counties were confirmed rabid (Figure A, B). The 28 rabid skunks in 2018 was slightly greater than the annual average of 25 in the preceding ten years, 2008-2017. The greatest numbers of rabid skunks were reported in Tuolumne (8), Amador (6), and Sacramento (6) counties.

Foxes

A total of 27 foxes from 20 counties were tested for rabies in 2018. The three rabid foxes confirmed in 2018 are below the annual average of eight foxes reported in the previous 10 years, 2008-2017 (Figure B). Rabies virus from the rabid fox in Madera County was identified as California skunk RVV and virus from the rabid fox in Humboldt County was characterized as Yuma myotis RVV. RVV information was not available for the rabid fox from Sutter County.

Raccoon

Of 193 raccoons tested in 2018, rabies was identified in one raccoon in Tuolumne County. The raccoon was discovered in a residential backyard during the day and appeared unable to extricate itself from between a shrub and the side of the house. The raccoon snapped at the air, clawed, and attacked when animal control attempted to restrain it. The raccoon was infected with the California skunk RVV.

Domestic Animals

In 2018, 2,694 domestic animals (dogs, cats, horses, cattle, goats, and sheep) were tested for rabies, none of which was confirmed rabid.

Rabies in Humans

Rabies was not diagnosed in any California resident in 2018. Three cases of rabies were diagnosed in California residents in the previous ten years (2008- 2017), the most recent in a Contra Costa County resident in 2012.

Rabies in the United States

A total of 4,951 cases of animal rabies and three cases of human rabies were reported in the U.S. in 2018 [Ma et al 2020]. Wild animals accounted for 92.7 percent of all cases; bats represented the largest proportion of cases (33.0%), followed by raccoons (30.3%), skunks (20.3%), and foxes (7.2%). Domestic animals accounted for 7.3 percent of all rabid animals and included 63 dogs and 241 cats. Three cases of human rabies were

identified in residents of Delaware, Florida, and Utah.

Discussion

Bats were the most frequently reported rabid animal in California in 2018, as they have been each year since 2000. Over the last 15 years, the number of rabid bats in California has ranged from a low of 137 (2008) to a high of 227 (2012), accounting for 62 to 95 percent of all rabid animals identified. These apparent fluctuations likely represent a combination of the normal variation in rabies dynamics in an adapted species and the inherent imprecision of a surveillance program that is dependent on convenience sampling. Rabies in indigenous, insectivorous bats in the U.S. was recognized as an important public health concern only in the latter half of the 20th century. Rabies likely occurred in bats long beforehand, but as domestic dogs were the primary rabies reservoir in the U.S. and throughout the world, wildlife, including bats, were infrequently tested. Rabies virus was first detected in insectivorous bats in a yellow bat (*Dasypterus floridanus*) from Florida in 1953 [Venters 1954] and within three years had been detected in seven Florida bat species [Schneider 1957]. Today, rabid bats have been identified in all states except Hawaii and in 2017 were the most frequently reported rabid animals in the U.S. [Ma 2018].

An effective rabies surveillance program must include evaluation of RVVs to identify emergent mutations or extensive spillover that could signal a novel virus or enhanced potential for transmission to humans. In 2018, eight different bat RVVs were identified in 127 rabid bats of 10 different species in California. Most rabid bats were infected with RVVs associated with their own species. However, 11 rabid bats harbored RVVs typically associated with a bat species that differed from their own. For example, the Brazilian free-tailed bat RVV was detected in 68 Brazilian free-tailed bats, but also three pallid bats and one Yuma myotis. Similarly, the hoary bat RVV was detected in eight hoary bats, but also one big brown bat, one western red bat, and one Brazilian free-tailed bat. While certain RVVs tend to circulate within a bat species, all rabies viruses are capable of infecting any mammal and can spillover from adapted hosts to other species. Some gregarious bat species may roost with bats of other species and transmit rabies virus across species. Brazilian free-tailed bats, as the most common and widely distributed bat in California, have frequent opportunity for contact with other bat species. In contrast, the hoary bat, though also widespread, is typically solitary; but it can be aggressively territorial and may transmit rabies virus to other bats that challenge for roosting sites.

Skunks continued to be the second most reported rabid animal 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 Sacramento, account for nearly three quarters (178 of 247; 72%) of rabid skunks detected in the last ten years (2009-2018). The greatest number of rabid skunks in 2018 were reported from Tuolumne County; the eight cases represented a significant increase over the single rabid skunk reported from the county in 2017. Tuolumne County reported between 1 and 12 rabid skunks each year in the first decade of the 21st century (2001-2010) but reported no rabid skunks during the following six years (2011-2016). Previous analyses of national public health

surveillance data suggested that epizootics of skunk rabies follow a six to eight-year cycle in the U.S. Midwest [Gremillion-Smith 1988]. The relatively few skunk rabies cases detected each year in California make discernment of temporal patterns challenging; nonetheless, over the past few decades, several enzootic counties (e.g., Tuolumne County in 2018) have witnessed sudden surges of cases (6-16 per year) following a span of 3-7 years in which few to no cases were reported. As these apparent spikes are out-of-phase across enzootic counties, they likely represent localized phenomena particular to regional subpopulations of skunks and less attributable to widespread extrinsic determinants (e.g., climate, precipitation).

Three rabid foxes were reported in 2018 from the north coast (Humboldt County), Sacramento Valley (Sutter County), and central Sierra Nevada foothills (Madera County). As there is no wild canid RVV in California, cases of rabies in foxes represent spillover of rabies virus from other species and can occur wherever foxes intersect with RVV host species. Of the 13 rabid foxes identified in 2016-2018 for which RVV was determined, six were California skunk, four California myotis bat, two Brazilian free-tailed bat, and one Yuma myotis bat RVV. It is critical to determine the RVV infecting California foxes to verify that neither a wild or domestic canine RVV has been introduced to California nor that any indigenous bat or skunk RVV has mutated to be readily maintained and transmitted among canine hosts.

Rabies was reported in one raccoon from Tuolumne County in 2018. Rabies is rarely detected in raccoons in California; only four rabid raccoons were reported between 1998 and 2017, the most recent prior to 2018 from El Dorado County in 2012. There is no indigenous raccoon RVV in California and all rabies in this species represent spillover from bats or skunks. Elsewhere in the U.S., raccoon rabies represents a significant threat to animal and human health. In 2017, 1,275 rabid raccoons were reported nationwide and represented the predominant animal identified with rabies in 18 states, the District of Columbia, and New York City [Ma 2018]. Of 146 rabies cases in domestic animals that same year for which the RVV was determined, 76 (52%) were infected with the raccoon RVV. The raccoon RVV was also detected in several wildlife species, including skunks, foxes, coyotes, bobcats, deer, groundhogs, and opossums. Since 2003, three U.S. residents have died from rabies following infection with the raccoon RVV.

Prior to the mid-1970s, raccoon rabies was confined to the southeastern U.S., in an enzootic area extending north to South Carolina and west to Alabama. Purposeful translocation of raccoons from Florida to West Virginia in 1977 resulted in an epizootic of raccoon rabies that spread rapidly in the succeeding years north to Maine and New Brunswick and west to Ohio and southwestern Alabama. Both the National Rabies Management Program (NRMP), inaugurated by the U.S. Department of Agriculture, Animal and Plant Health Inspection Service (USDA-APHIS) in 1999, and the international North American Rabies Management Plan (NARMP), signed in 2008, were created specifically to halt the geographic expansion of raccoon RAVV to other states and countries. In 1997, the USDA licensed the first oral rabies vaccine (Raboral V-RG®) for use in raccoons. Each year, approximately eight million doses of vaccine, delivered in a fishmeal bait, are dispersed across 111,000 km² in 14 states to establish a containment barrier to the epizootic [Slate 2005], at an estimated cost (in

2019 U.S. dollars) of \$150 to \$390/km² [Foroutan 2000].

The long-term goal of the NRMP to eradicate raccoon RVV from the U.S. faces formidable hurdles. Raccoons are not merely prevalent across the continent, but are well adapted to survive and thrive in diverse habitats, including developed, residential areas. Raccoons are common “urban wildlife”, subsisting on pet food, garbage, backyard fruit trees, and other resources common around human habitation. Whereas the chief rabies host species in California, viz. skunks and bats, are generally timid and shy away from human contact, raccoons are acclimatized to human activity and are more likely to behave aggressively toward humans and pets. Furthermore, 33% to 50% of raccoons submitted for rabies testing in enzootic states were positive [Jenkins 1988], compared to approximately 10% of bats and skunks tested in California. In states where raccoon RVV is enzootic, rabies PEP is administered two and six times more frequently per capita than in states where skunk and bat RVVs predominate, respectively [Christian 2009]. Less than five years following introduction of raccoon RVV into Massachusetts, the annual number of rabies PEP administrations increased 26-fold [Kreindel 1998].

Translocation of raccoon RVV into California would not only undermine decades of containment and control, but seriously threaten people and animals. By California regulations, any person desiring or intending to import a raccoon into California must apply for and be granted permits from both the California Department of Fish and Wildlife and CDPH. Among the conditions of the latter permit are a signed verification by a veterinarian prior to importation that the animal is healthy and has no evidence of infectious diseases, and strict quarantine of the animal immediately upon entry into the state for 90 days at a facility approved by CDPH.

References

Christian KA, Blanton JD, Auslander M, Rupprecht CE. Epidemiology of rabies post-exposure prophylaxis United States of America, 2006-2008. *Vaccine* 2009; 27:7156-7161.

Foroutan P, Meltzer MI, Smith KA. Cost of distributing oral raccoon-variant rabies vaccine in Ohio: 1997-2000. *J Am Vet Med Assoc* 2002; 220:27-32.

Gremillion-Smith C, Woolf A. Epizootiology of skunk rabies in North America. *J Wild Dis* 1988; 24:620-626.

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

Kreindel SM, McGill M, Meltzer MI, Rupprecht CE, DeMaria A. The cost of rabies postexposure prophylaxis: one state’s experience. *Publ Health Rep* 1998;113:247–251.

Ma X, Monroe BP, Cleaton JM, et al. Rabies surveillance in the United States during 2017. *J Am Vet Med Assoc* 2018; 253:1555-1568.

Ma X, Monroe BP, Cleaton JM, et al. Rabies surveillance in the United States during 2018. *J Am Vet Med Assoc* 2020; 256:195-208.

Schneider NJ, Scatterday JE, Lewis AL, Jennings WL, Venters HD, Hardy AV. Rabies in bats in Florida. *Am J Publ Health* 1957; 47:983-989.

Slate D, Rupprecht CE, Rooney JA, Donovan D, Lein DH, Chipman RB. Status of oral rabies vaccination in wild carnivores in the United States. *Virus Res* 2005; 111:68-76.

Venters HD, Hoffert WR, Scatterday JE, Hardy AV. Rabies in bats in Florida. *Am J Publ Health* 1954; 44:182.

Table A. Reported cases of rabies in animals, California, 2018.

COUNTY	BAT	SKUNK	CAT	DOG	COYOTE	FOX	HORSE	SHEEP	CATTLE	RACCOON	TOTAL
TOTAL	194	28	0	0	0	3	0	0	0	1	226
Alameda	2										2
-Berkeley City											0
Alpine											0
Amador	1	6									7
Butte	8										8
Calaveras		2									2
Colusa											0
Contra Costa	5										5
Del Norte											0
El Dorado	3	4									7
Fresno	2										2
Glenn	2										2
Humboldt	1					1					2
Imperial											0
Inyo											0
Kern	1										1
Kings	3										3
Lake	1										1
Lassen											0
Los Angeles	27										27
-Long Beach City											0
-Pasadena City											0
Madera	3					1					4
Marin	13										13
Mariposa											0
Mendocino											0
Merced											0
Modoc	1										1
Mono											0
Monterey	1	1									2
Napa											0
Nevada	1										1
Orange	11										11
Placer		1									1
Plumas											0
Riverside	7										7
Sacramento	15	6									21
San Benito											0
San Bernardino	4										4
San Diego	7										7
San Francisco	2										2
San Joaquin	5										5
San Luis Obispo	2										2
San Mateo	5										5
Santa Barbara	1										1
Santa Clara	10										10
Santa Cruz											0
Shasta	1										1
Sierra											0
Siskiyou											0
Solano	4										4
Sonoma	5										5
Stanislaus											0
Sutter	11					1					12
Tehama											0
Trinity	1										1
Tulare	3										3
Tuolumne	1	8							1		10
Ventura	11										11
Yolo	11										11
Yuba	2										2

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

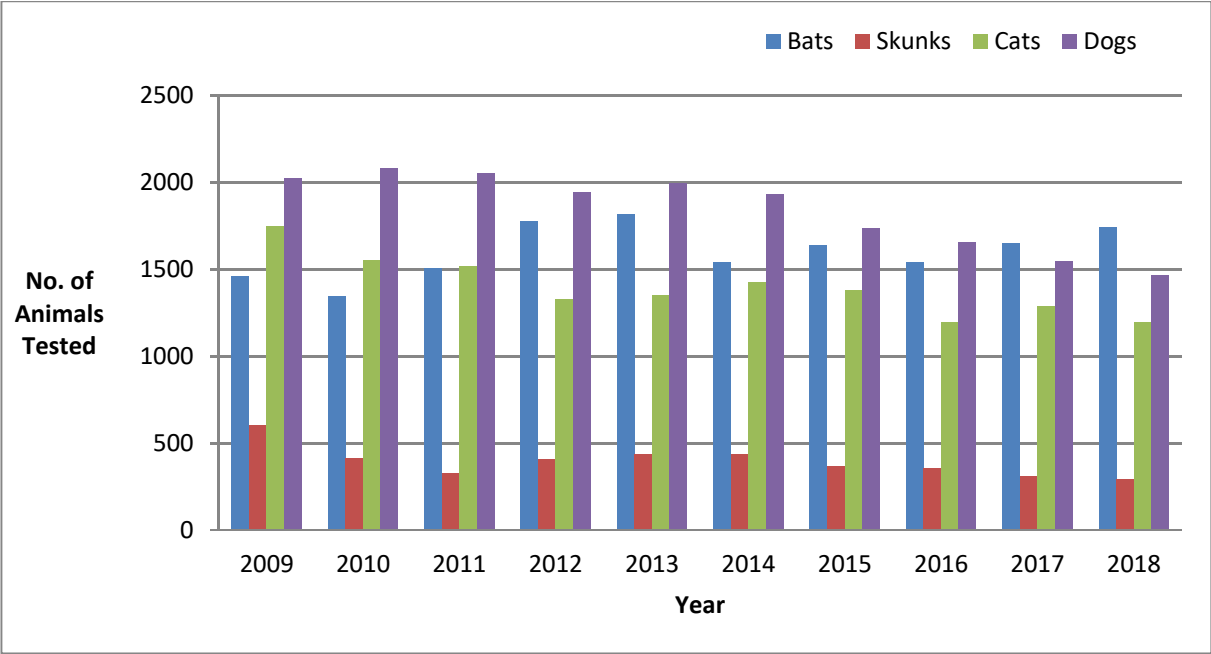


Figure A. Selected wild and domestic animals tested for rabies in California, 2009- 2018.

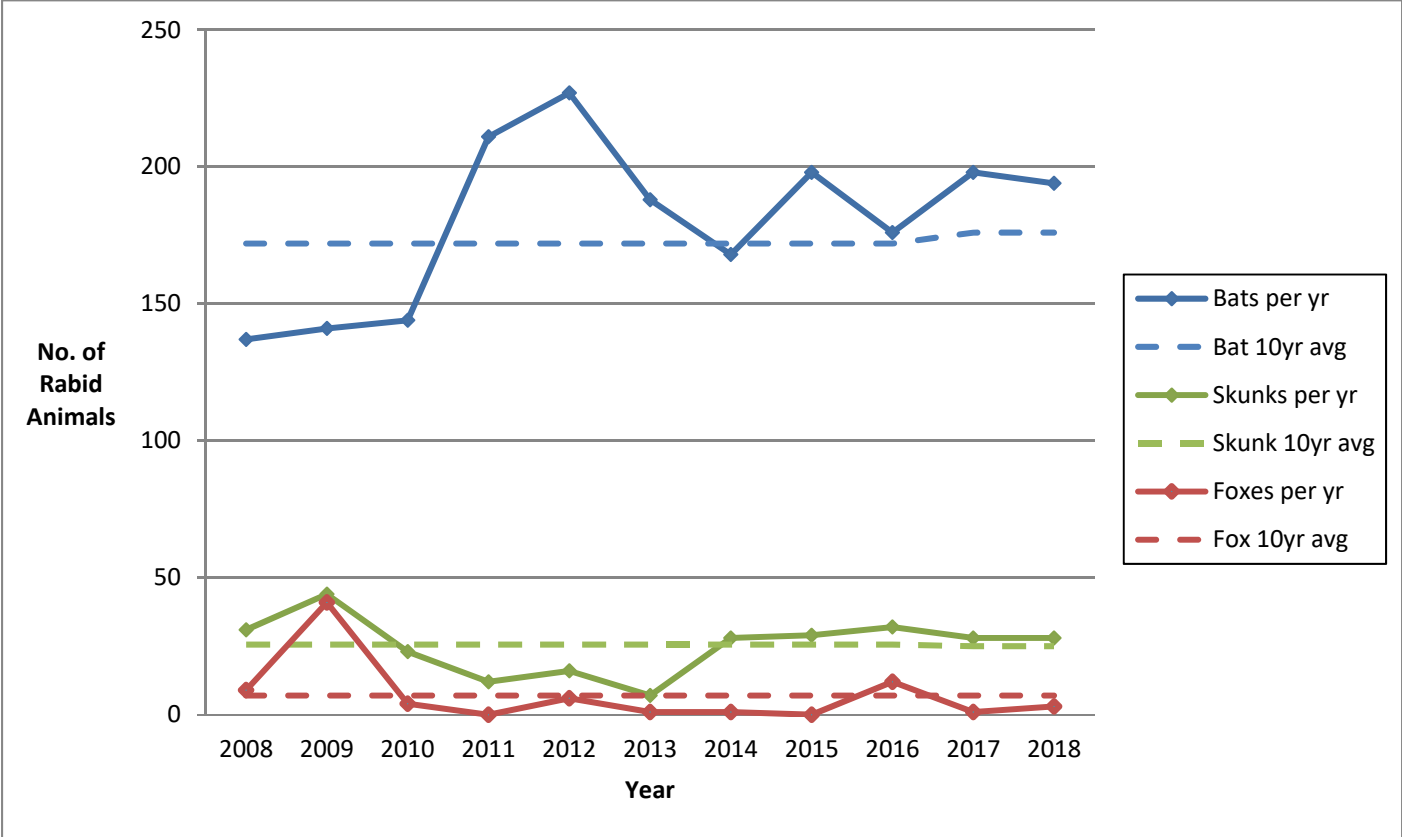


Figure B. Cases of rabies in wild animals in California, 2008-2018.

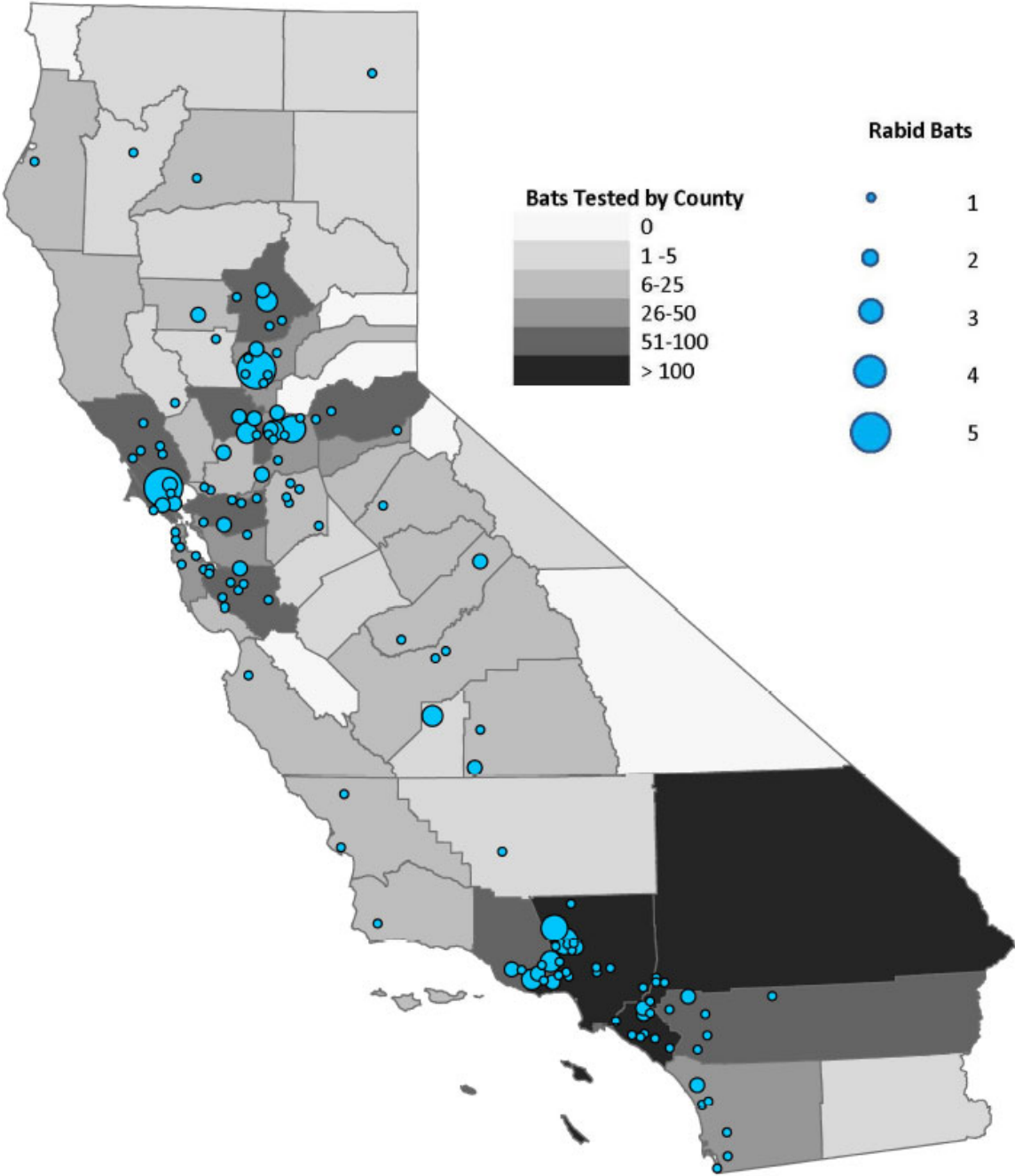


Figure C. Bats tested for rabies by county with positive cases by zip code of collection site, California, 2018.

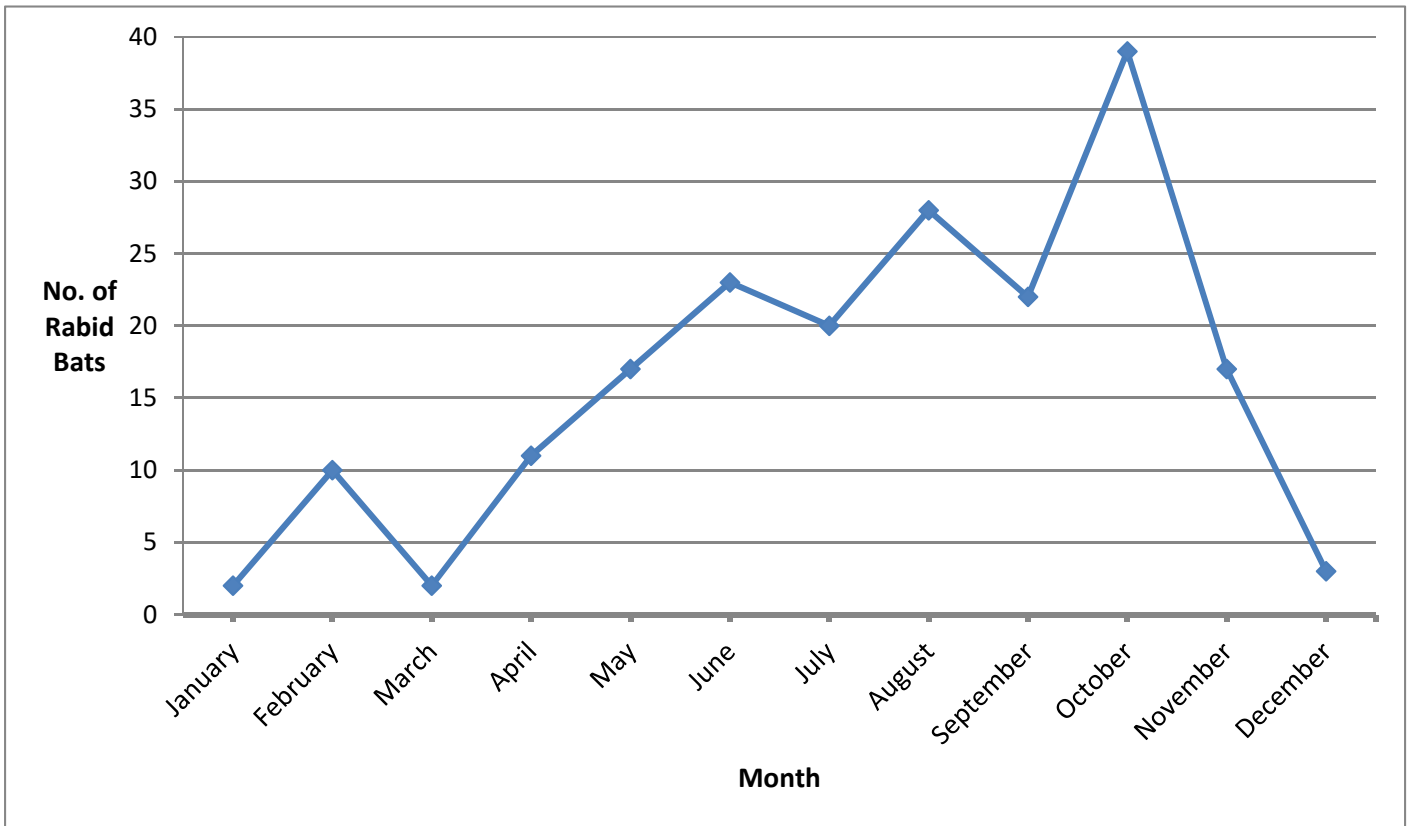


Figure D. Cases of rabies in bats by month of testing, California, 2018.

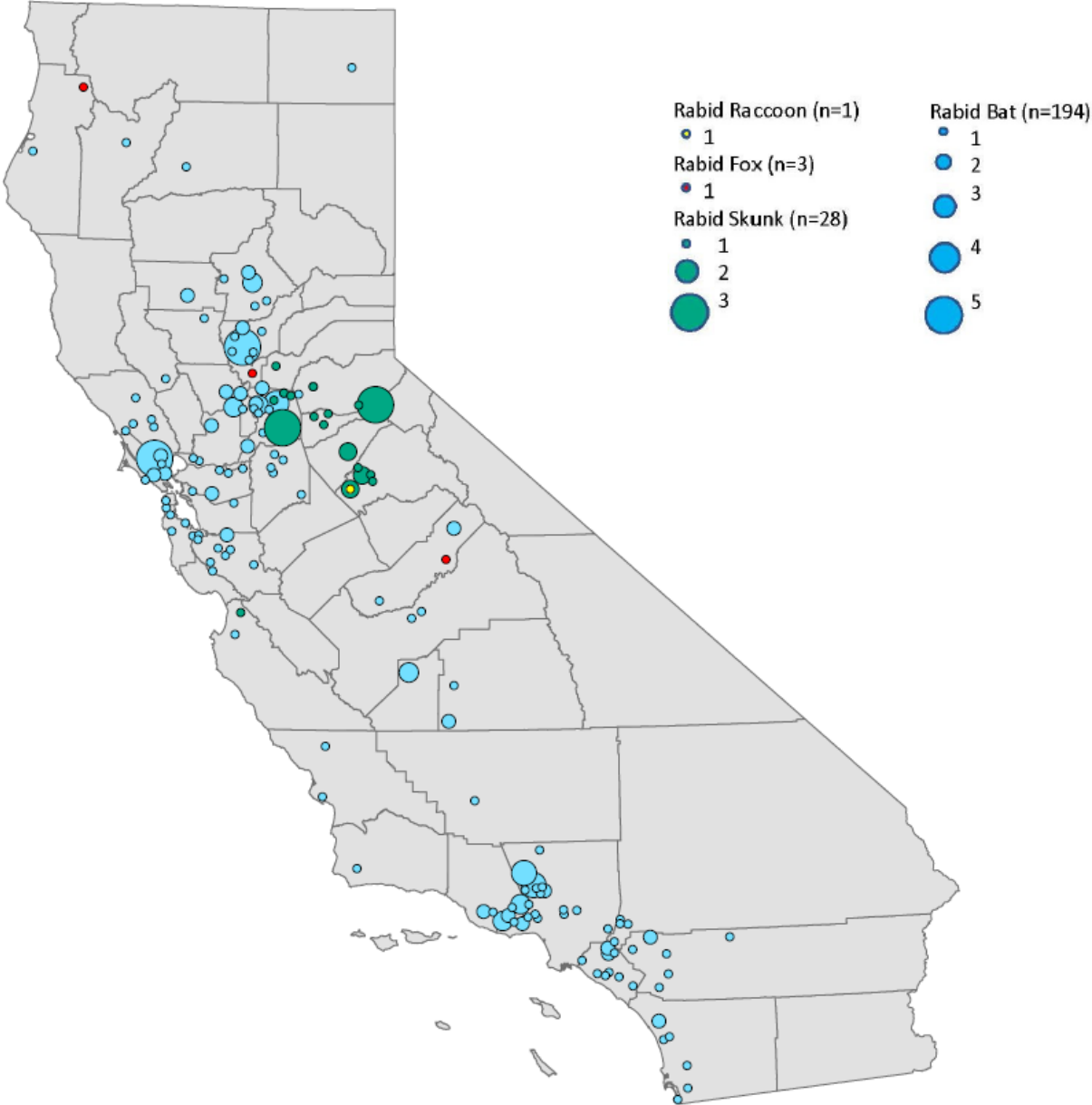


Figure E. Reported cases of rabies in wild animals by zip code of collection site, California, 2018.