

Rabies Surveillance in California

Annual Report 2019

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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 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 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. In 2019, 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 2019.

Rabies in Animals

In 2019, specimens from 4,993 animals were tested for rabies in California – approximately 13 percent fewer than the annual average of 5,747 specimens tested during the previous ten years, 2009-2018. Of the 53 counties that submitted at least one animal for rabies testing, the number of animals tested per county ranged from 1 to 606.

Rabies was confirmed in 276 animals, more than the 226 cases confirmed in 2018 and 26 percent above the annual average of 219 cases in 2009-2018 (Table A). One or more rabid animals were identified in 38 counties, which reported between 1 and 51 rabid animals each.

Wild Animals

Rabies was diagnosed in 274 wild animals in 2019, accounting for 99 percent of all rabid animals reported to CDPH. Bats (230, 83.3%) were the wild animal most frequently reported rabid, followed by skunks (41, 14.9%), and foxes (3, 1.1%).

Bats

A total of 1,755 bats from 52 counties were tested for rabies in 2019 (Figure A). The 230 rabid bats reported in 2019 is 30 percent higher than the annual average of 185 reported in the preceding ten years, 2009-2018 (Figure B). The greatest number of rabid bats (51) was reported in Los Angeles County, which reported the most rabid

bats in nine 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 44 percent of all rabid bats detected in California in 2019. Rabid bats were most frequently reported during the summer and early autumn months; roughly two thirds (151, 66%) of all rabid bats were reported in the five months of June through October (Figure D). Species was identified for 198 rabid bats: 91 Mexican free-tailed bats (*Tadarida brasiliensis*), 48 western pipistrelle (*Parastrellus hesperus*), 16 big brown bats (*Eptesicus fuscus*), 13 Yuma myotis (*Myotis yumanensis*), 11 California myotis (*Myotis californicus*), 10 Hoary bats (*Lasiurus cinereus*), 3 Western yellow bats (*Lasiurus xanthinus*), 2 Pallid bats (*Antrozous pallidus*), and 1 each silver-haired bat (*Lasionycteris noctivagans*), western red bat (*Lasiurus blossevillii*), little brown bat (*Myotis lucifugus*), and fringed myotis (*Myotis thysanodes*).

Skunks

A total of 252 skunks (*Mephitis mephitis*) from 32 counties were tested for rabies in 2019, of which 41 from 7 counties were confirmed rabid (Figure A, B). The 41 rabid skunks in 2019 was 65 percent greater than the annual average of 25 in the preceding ten years, 2009-2018. The greatest numbers of rabid skunks were reported in Tuolumne (19), Sacramento (8), Amador (4), and El Dorado (4) counties.

Foxes

A total of 22 foxes from 14 counties were tested for rabies in 2019. The three rabid foxes confirmed in 2019 are below the annual average of seven foxes reported in the previous 10 years, 2009-2018 (Figure B). Rabies virus from the rabid fox in Tuolumne County was identified as California skunk variant, and viruses from the rabid foxes in Shasta and Humboldt counties were both identified as *Myotis californicus* bat variant.

Domestic Animals

In 2019, 2,704 domestic animals (dogs, cats, horses, cattle, goats, sheep, and swine) were tested for rabies. Rabies was confirmed in two cats (Figure E) which was comparable to the annual average of 2.2 rabid domestic animals reported in the previous 10 years, 2009-2018.

In October 2019, rabies virus was detected in an approximately 14-week-old kitten from Fresno County that had been euthanized and tested for rabies after biting a household member. CDPH VRDL identified the virus as consistent with the Mexican free-tailed bat (*Td. brasiliensis*) RVV. The rabid kitten shared the premises with 14 other semi-feral cats; four dogs at the residence reportedly had no contact with the cats. The cats were placed under 180-day confinement for observation. Rabies vaccine was administered to two dogs and the other two dogs were current on rabies vaccination; all dogs were confined for observation. The bite victim and one other member of the household initiated rabies PEP.

In December 2019, a three-year-old, spayed female, unvaccinated cat from Tuolumne County was observed by the owner to display neurological signs after going missing for

two days. The cat was euthanized and rabies testing was inconclusive at the San Joaquin County Public Health Laboratory, but rabies virus was verified by DFA and PCR at CDPH VRDL. The virus was consistent with the California skunk RVV. One other cat and several dogs which shared the premises reportedly were housed separately and had no contact with the rabid cat. The owner who had provided intimate care to the cat during its illness received PEP.

Rabies in Humans

Rabies was not diagnosed in any California resident in 2019. Two cases of rabies were diagnosed in California residents in the previous ten years (2009-2018), the most recent in a Contra Costa County resident in 2012.

Rabies in the United States

A total of 4,690 cases of animal rabies were reported in the U.S. in 2019 [Ma et al 2021]. Wild animals accounted for 91.8 percent of all cases; raccoons represented the largest proportion of cases (32.9%), followed by bats (29.6%), skunks (19.5%), and foxes (7.7%). Domestic animals accounted for 8.2 percent of all rabid animals and included 39 cattle, 66 dogs, and 245 cats. No cases of human rabies were identified in the U.S. in 2019.

Discussion

The 276 rabid animals identified in 2019 represent the greatest number of animal rabies cases reported in California in a single year in nearly two decades. However, in contrast to 2001, when rabid skunks (151) represented nearly half of the 321 animal rabies cases reported, bats were the most frequently reported rabid animal in California in 2019, as they have been each year since 2000. Over the last 20 years, bats have accounted for 62 to 95 percent of all rabid animals identified in California. The 230 rabid bats observed in 2019 surpassed the previous record of 227 in 2012, though the 1755 bats tested was only seven percent higher than the mean of 1645 per annum since 2000. It is unclear if the increased number of rabid bats represents a true surge in infection in California bat populations or is an artifact of passive surveillance. Numerous factors must align for a bat with rabies to be reported as a case, including: being present in an area where humans reside or visit, being observed by a human, being reported to local authorities, being either captured alive or its carcass collected within a narrow window of a few days after death, local officials deciding to test the bat for rabies, and rabies infection to be at a sufficiently advanced stage to be detectable in brain tissue by standard DFA. The bat rabies cases that are reported for public health surveillance likely paradoxically represent both an over-estimate of the proportion of bats that are rabid (i.e., ill bats are more likely to be observed, collected, and tested) as well as an under-representation of the incidence of rabies in the collective wild bat population.

It is unclear the degree to which extensive wildfires in recent years may have impacted California bat colonies and circulation of bat RVVs in 2019. The California Department of Forestry and Fire Protection (Cal Fire) reported nearly 8000 fires in California in 2018 which burned nearly two million acres. This devastation represented a 28%

increase in acres burned over 2017 and nearly 200% increase over 2016. The bat species most commonly identified as rabid in 2018 and 2019—viz. Brazilian free-tailed bats (*Tadarida brasiliensis*), western pipistrelle (*Parastrellus hesperus*), Hoary bats (*Laisurus cinereus*), Yuma myotis (*Myotis yumanensis*), and big brown bats (*Eptesicus fuscus*)—roost chiefly in buildings, tunnels, caves, and rock outcroppings rather than trees and other foliage. These species may be less vulnerable to detrimental habitat loss due to wildfire than chiefly arboreal species. Preferentially arboreal species may seek alternatives within buildings and other artificial structures that bring them into closer proximity to humans. Reduction in available roosting areas may lead to crowding and greater opportunity for transmission of pathogens such as rabies virus. Increased competition for limited roosting sites may also stress bats rendering them more susceptible to infection, recrudescence of latent infection, and virus shedding [Subudhi 2019].

Vagile species such as bats may be more capable of compensating for the adverse effects of wildfire than sessile or terrestrial wildlife. In fact, recent research in the Sierra Nevada suggests that wildfires may benefit some insectivorous bats through clearing understory vegetation and removing obstacles to foraging echolocation [Steel 2019]. Historically, natural seasonal fires which burned at mild or moderate severity left in their wake a mix of vegetation and habitat types. These punctuated burns expanded accessibility for bats, particularly species that forage along habitat edges and transitions. However, decades of fire suppression, multi-year droughts, and hotter summers have contributed to unnaturally intense and widespread fires that create homogenous high-severity patches rather than the diverse mosaic of burn severities (“pyrodiversity”) that support bat species richness. Reduced biodiversity of bat species may facilitate perpetuation of microbial pathogens, such as rabies virus, leading to greater incidence among host species and increased risk of transmission to non-hosts such as humans [Patil 2017]. Industrial deforestation has been cited as possibly contributing to displacement and concentration of bats around human habitations, leading to the emergence of other bat-borne zoonotic viruses such as Nipah and Hendra [Halpin 2000] and the SARS-type coronaviruses [Afelt 2018].

Skunks continued to be the second most frequently 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 over three quarters (190 of 244; 78%) of rabid skunks detected in the last ten years (2010-2019). The 19 rabid skunks reported in 2019 from Tuolumne County were the most for California and an historical high for the county. Tuolumne County reported only two rabid skunks were reported in 1990-1997, an average of nearly four rabid skunks each year from 1998-2010, then not a single rabid skunk during 2011-2016. These observations align with previous analyses of national public health surveillance data in the U.S. Midwest that suggest that epizootics of skunk rabies follow a six to eight-year cycle [Gremillion-Smith 1988].

Rabies was identified in two domestic cats in 2019. Prior to mandated vaccination of domestic dogs in California in the 1950s, an average of 18 rabid cats were observed in California each year from the 1920s through 1940s. Following the elimination of the

canine RVV from the U.S., rabies in domestic cats occurs through spillover from bats or skunks, resulting in only 1-2 rabid cats detected in California each year since 2000. Nationwide, the number of rabid cats exceeds the number of rabid dogs by nearly four-to-one [Ma 2020]. Several factors likely contribute to this disproportionate risk including that cats are often allowed to roam freely off their home property, cats' natural predatory predisposition, and the significantly smaller proportion of pet cats vaccinated against rabies. Thirty-six states and the District of Columbia include domestic cats in their rabies vaccination statutes or regulations. Rabies vaccination is not mandated for cats by California regulation, though some cities and counties require vaccination by local ordinance. Because of the widespread risk of rabies from wildlife, the American Animal Hospital Association and the American Academy of Feline Practitioners in their 2020 vaccination guidelines included rabies as one of the core vaccines to be administered to all cats [Stone 2020].

All rabies vaccines licensed for cats in the U.S. specify a minimum age of 12 weeks or 3 months for the first administered dose. One of the rabid cats in California in 2019 was approximately 12-14 weeks old and thereby too young to have been vaccinated at the putative time of its exposure weeks earlier. Kittens rely on passive transfer of protective maternal antibodies principally via colostrum in the first 1-2 days of life. All cats that reside in rabies enzootic areas, including pregnant queens, should be kept current on rabies vaccination to protect themselves, their offspring, and their owners.

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Table A. Reported cases of rabies in animals, California, 2019.

COUNTY	BAT	SKUNK	CAT	DOG	COYOTE	FOX	HORSE	SHEEP	CATTLE	RACCOON	TOTAL
TOTAL	230	41	2	0	0	3	0	0	0	0	276
Alameda	7										7
-Berkeley City											0
Alpine											0
Amador		4									4
Butte	5										5
Calaveras	1										1
Colusa											0
Contra Costa	8										8
Del Norte											0
El Dorado	1	4									5
Fresno	4		1								5
Glenn	2										2
Humboldt	3					1					4
Imperial											0
Inyo	3										3
Kern											0
Kings	1										1
Lake											0
Lassen											0
Los Angeles	50										50
-Long Beach City											0
-Pasadena City	1										1
Madera		1									1
Marin	16										16
Mariposa	2										2
Mendocino											0
Merced											0
Modoc											0
Mono											0
Monterey											0
Napa											0
Nevada											0
Orange	15										15
Placer	2										2
Plumas											0
Riverside	13										13
Sacramento	6	8									14

Table A (continued). [Reported cases of rabies in animals, California, 2019.](#)

COUNTY	BAT	SKUNK	CAT	DOG	COYOTE	FOX	HORSE	SHEEP	CATTLE	RACCOON	TOTAL
San Benito											0
San Bernardino	7										7
San Diego	7										7
San Francisco	3										3
San Joaquin	3	3									6
San Luis Obispo	1										1
San Mateo	3										3
Santa Barbara	6										6
Santa Clara	9										9
Santa Cruz											0
Shasta						1					1
Sierra											0
Siskiyou	1										1
Solano	4										4
Sonoma	5										5
Stanislaus		2									2
Sutter											0
Tehama	2										2
Trinity											0
Tulare	8										8
Tuolumne		19	1			1					21
Ventura	9										9
Yolo	15										15
Yuba	7										7

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

Figure A. Selected wild and domestic animals tested for rabies in California, 2010-2019.

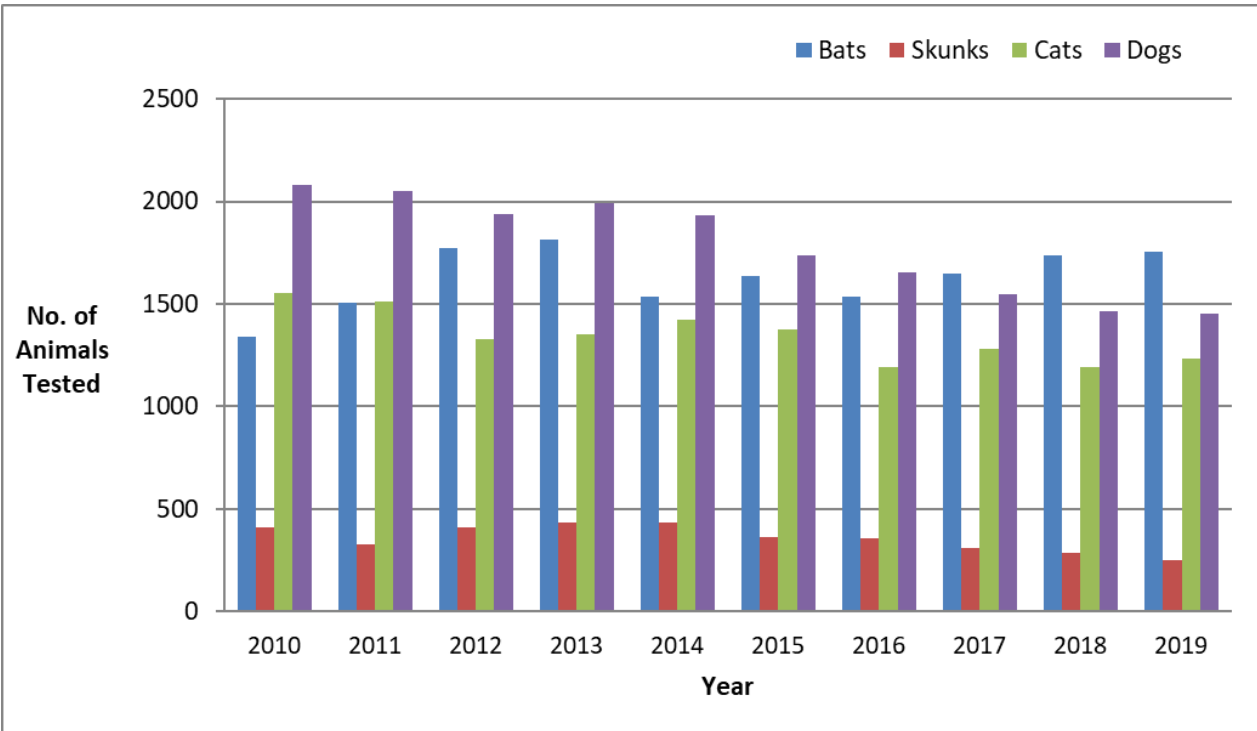


Figure B. Cases of rabies in wild animals in California, 2009-2019. (Ten-year averages represent 2009-2018 data.)

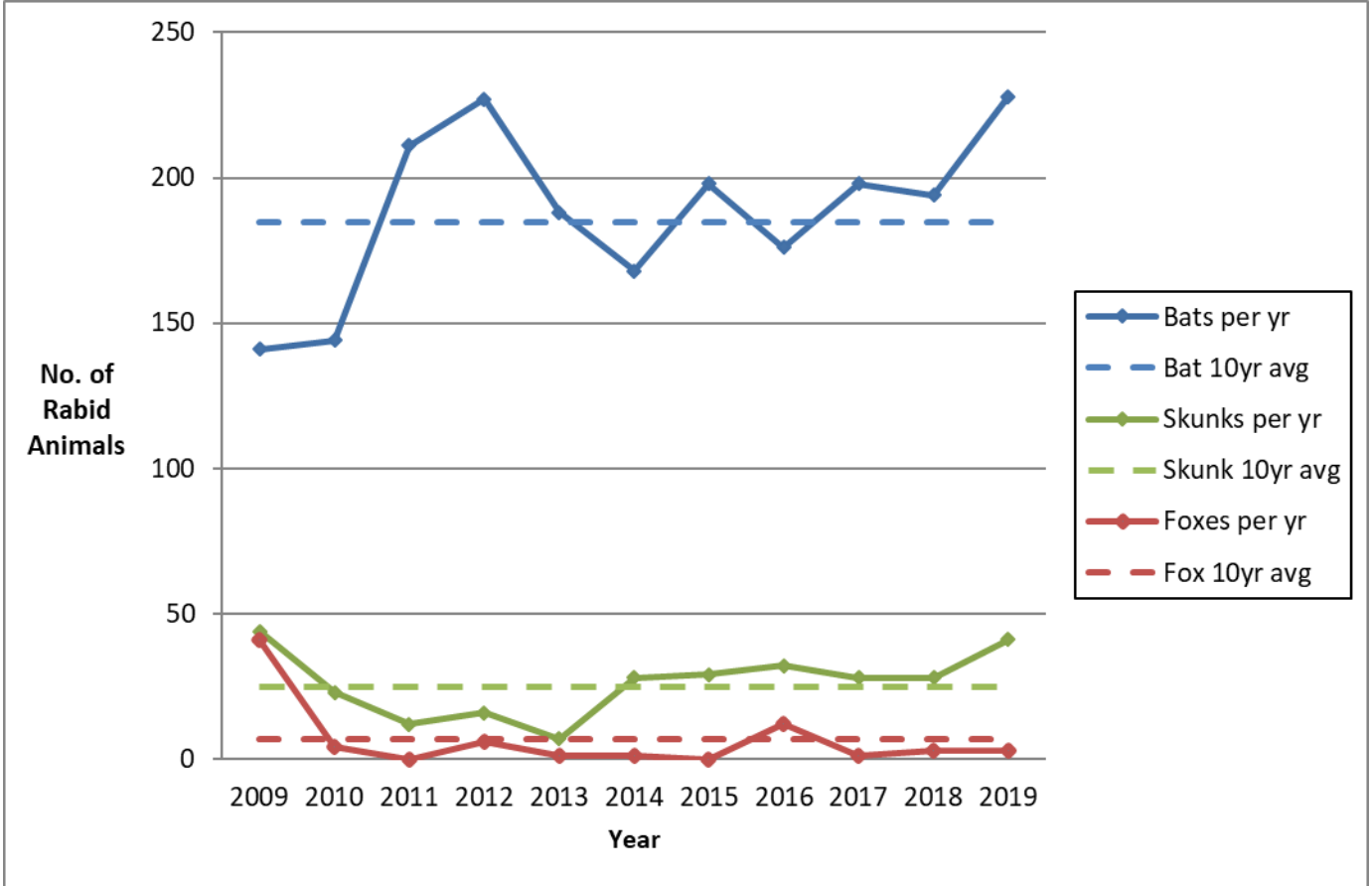


Figure C. Bats tested for rabies by county with positive cases by zip code of collection site, California, 2019.

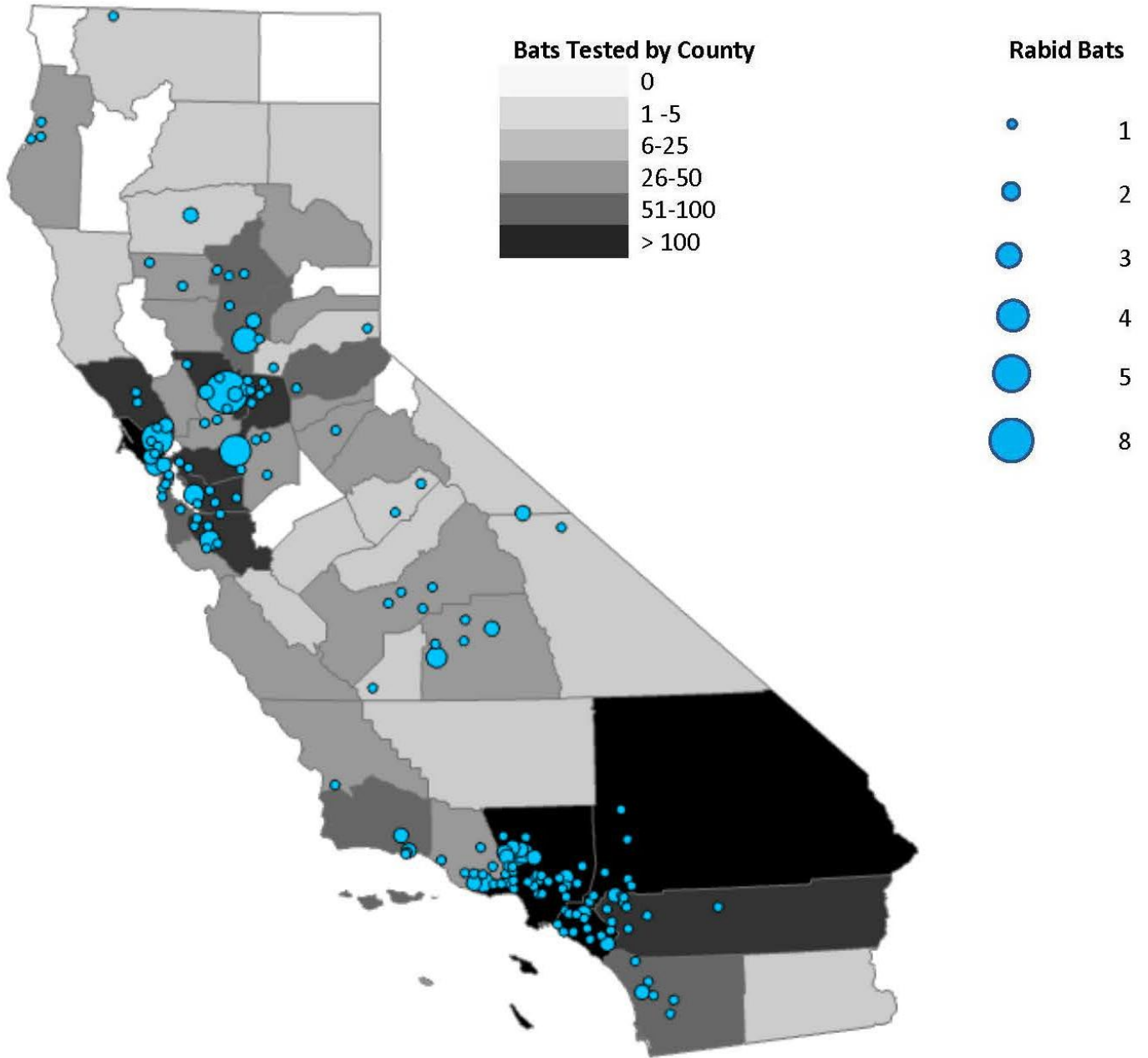


Figure D. Cases of rabies in bats by month of testing, California, 2019.

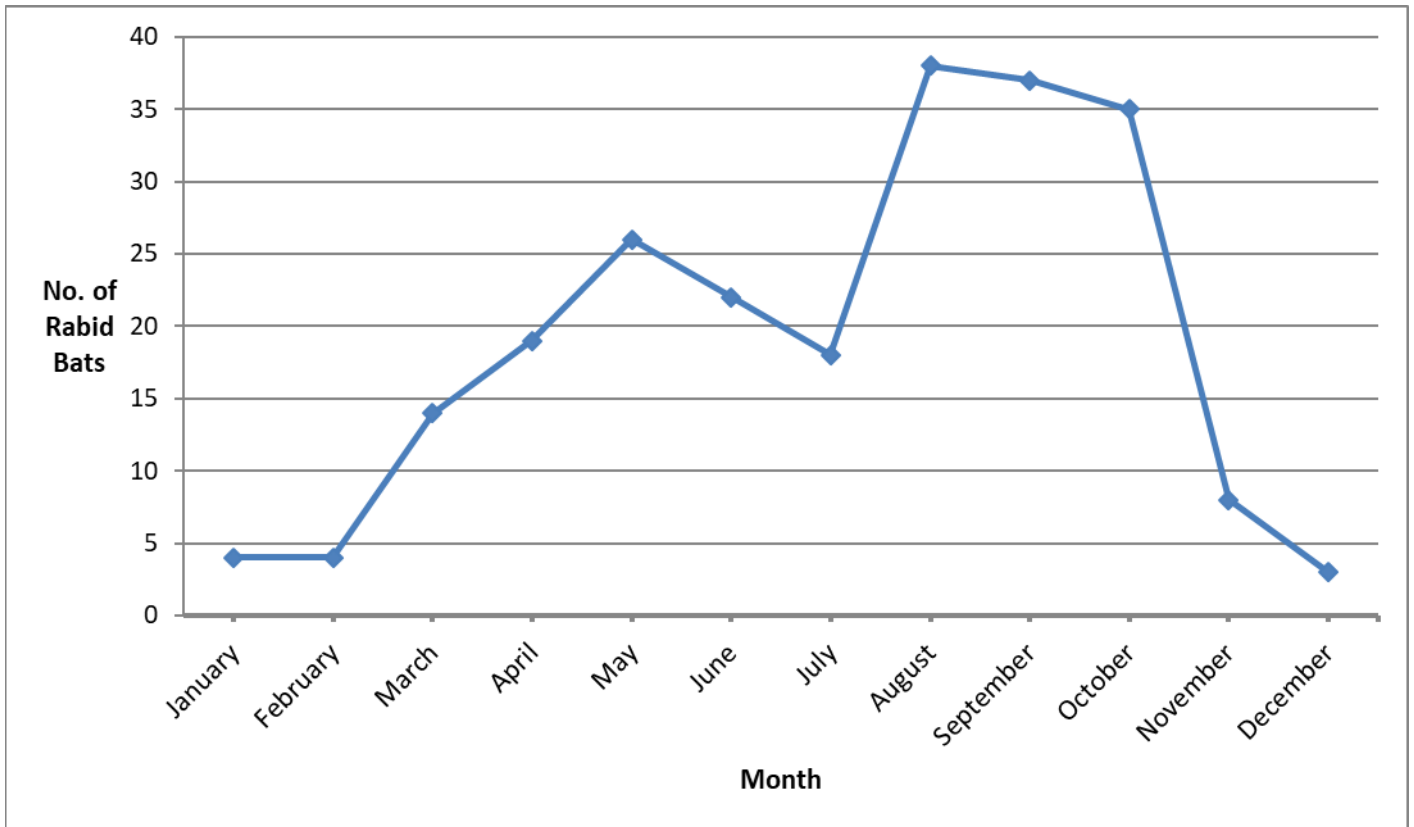


Figure E. Reported cases of rabies in wild animals by zip code of collection site, California, 2019.

