

Rabies Surveillance in California

Annual Report 2017

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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. Disease progresses 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 (RABVV) are maintained in certain mammalian species, but all rabies viruses are capable of infecting any mammal, including humans. In California, bat RABVVs exist throughout the state, while the California skunk RABVV is found mostly north of the Tehachapi mountain range. Domestic animals (dogs, cats, and livestock) can be infected with these RABVVs 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 2017, 34 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 2017.

Rabies in Animals

In 2017, specimens from 5,133 animals were tested for rabies in California – approximately 16 percent fewer than the annual average of 6,121 specimens tested during the previous ten years, 2007-2016. Of the 55 counties that tested at least one animal for rabies, the number of animals tested per county ranged from 1 to 593.

Rabies was confirmed in 231 animals, similar to the 226 cases confirmed in 2016 and slightly above the annual average of 214 cases in 2007-2016 (Table A). One or more rabid animals were identified in 37 counties, which reported between 1 and 33 rabid animals each.

Wild Animals

Rabies was diagnosed in 227 wild animals in 2017, accounting for 98 percent of all rabid animals reported to CDPH. Bats (198, 85.7%) were the wild animal most frequently reported rabid, followed by skunks (28, 12.1%) and foxes (1, 0.4%).

Bats

A total of 1,646 bats from 52 counties were tested for rabies in 2017 (Figure A). The 198 rabid bats reported in 2017 is higher than the annual average of 180 reported in the previous ten years, 2007-2016 (Figure B). The greatest number of rabid bats (33) 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 48 percent of all rabid bats detected in California in 2017. Rabid bats

were most frequently reported during the summer and early autumn months; roughly two thirds of all rabid bats (130, 66%) 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 Canyon bats (*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 308 skunks from 37 counties were tested for rabies in 2017, of which 28 from 7 counties were confirmed rabid (Figure A, B). The 28 rabid skunks in 2017 was slightly greater than the annual average of 25 in the preceding ten years, 2007-2016. The greatest numbers of rabid skunks were reported in El Dorado (9) and Amador (8) counties.

Foxes

A total of 41 foxes from 22 counties were tested for rabies in 2017. The one rabid fox confirmed in 2017 is below the annual average of eight foxes reported in the previous 10 years, 2007-2016 (Figure B). The VRDL identified the virus infecting the rabid fox in Napa County as consistent with the Brazilian free-tail bat (*T. brasiliensis*) RABVV.

Domestic Animals

In 2017, 2,840 domestic animals (dogs, cats, horses, cattle, goats, and sheep) were tested for rabies. Rabies was confirmed in three dogs and one cat (Figure E), slightly more than the mean of 1.7 domestic animal rabies cases per year in the previous ten years, 2007-2016.

In February 2017, a 15-month-old, female, spayed, unvaccinated "pitbull mix" dog from Trinity County presented to a local veterinarian with instability, dropped jaw, and seizures for the preceding two days. The dog was hospitalized and treated with subcutaneous fluids and phenobarbital, but its neurologic condition deteriorated overnight. The dog was euthanized and rabies virus was detected in brain tissue by the Humboldt County Public Health Laboratory. The VRDL identified the virus as consistent with the California skunk RABVV. The rabid dog was reported to have killed a skunk approximately six weeks prior to the dog's death. Six unvaccinated dogs identified as having had contact with the rabid dog in the days preceding its death were euthanized. One currently vaccinated dog that had contact was revaccinated and placed into 30-day confinement. A total of 13 persons--7 family members and friends, and 6 veterinary staff--who had contact with the rabid dog were advised to receive PEP.

In April 2017, a five-week-old, male Pomeranian-mix puppy from Amador County presented to a local veterinarian with dyspnea, lethargy, and mucoid ocular discharge. The owner reported that approximately ten days earlier, the puppy sustained a facial laceration during an encounter with a skunk. The puppy was released to the owner with oral antibiotics and subcutaneous fluids but died two days later. The puppy was relinquished to local animal control and rabies virus was detected in brain tissue by San Joaquin County Public Health Laboratory. A total of 18 persons--14 members of the

owner's family and 4 veterinary staff—who had contact with the puppy were advised to receive PEP. The rabid puppy's four littermates and their mother were ordered into 180-day confinement at the shelter. In late June, a second puppy from the litter died. Rabies virus was detected in brain tissue from the second puppy by San Joaquin County Public Health Laboratory. The VRDL identified the virus as consistent with the California skunk RABVV. The adult dog and remaining three puppies were euthanized. Brain tissue from only the bitch was submitted for rabies testing and was negative.

In June 2017, an approximately two-year-old, female, unowned cat in Sacramento County was observed to have apparent difficulty walking. A local resident collected the cat and presented it to a veterinarian who suspected rabies. The cat was euthanized and rabies virus was detected in brain tissue by the Sacramento County Public Health Laboratory. The VRDL identified the virus as consistent with the California skunk RABVV. The rabid cat shared the premises with ten other cats—three adult cats and a nursing queen with six kittens—as well as dogs, goats, and a pot-bellied pig. The cats were collected and euthanized; the other domestic animals were placed under 180-day confinement for observation. Two adults and three children who played with some of the cats received rabies PEP, though none were known to have been bitten or scratched. Two veterinary staff also received PEP.

Rabies in Humans

Rabies was not diagnosed in any California residents in 2017. Three cases of rabies were diagnosed in California residents in the previous ten years (2007-2016), the most recent in a Contra Costa County resident in 2012.

Rabies in the United States

A total of 4,454 cases of animal rabies and two cases of human rabies were reported in the U.S. in 2017 [Ma et al 2018]. Wild animals accounted for 91.0 percent of all cases; bats represented the largest proportion of cases (32.2%), followed by raccoons (28.6%) and skunks (21.1%). Domestic animals accounted for nine percent of all rabid animals and included 62 dogs and 276 cats. California rabid animals accounted for 4.5 percent of all animal rabies cases nationwide in 2017. Two cases of human rabies were identified in residents of Delaware and Florida.

Discussion

Bats were the most frequently reported rabid animal in California in 2017, as they have been each year since 2000. Over the last 15 years, the number of rabid bats 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. Similarly, despite the diverse factors that must align for a rabid bat to be observed, reported, collected, and tested, the proportion of bats submitted for testing that were confirmed rabid has remained consistently between 9 percent and 14 percent during the last 15 years. These steady surveillance figures suggests that rabies viruses are established, well-adapted, and sustained at a stable level in native bat populations.

Rabies was detected in at least nine different species of bats in 2017. The bat species represented vary broadly in their behavior characteristics, geographic ranges, and habitat preferences. Taken together, these species encompass a variety of roosting

sites by both type—trees, caves, buildings, and bridges—and frequency, with some species establishing permanent colonies and others relocating to new roosts each night after foraging. Individuals of some of these bat species may forage up to 65 km from their roosts. The geographic ranges of these bat species vary from only the southernmost counties (Western yellow bat), to the Sacramento and San Joaquin valleys (Canyon bat), to the entire state (Brazilian free-tailed bat and big brown bat). Finally, all species of bats identified as rabid in California in 2017 are year-round residents (ie, non-migratory). Even though these non-migratory bats may reduce their activity during cooler months, some species are tolerant of sub-freezing temperatures and may periodically emerge from hibernacula to forage during warmer winter days. The diversity of bat species represented in the 2017 case reports suggests that a rabid bat may be encountered in nearly any part of California, at any time of the year.

Reported cases of skunk rabies in California have decreased markedly over the past few decades. In 1985, 402 cases of skunk rabies were reported, but this number dropped to below 100 in 2000, and to less than 50 by 2003. In the last ten years (2008-2017), an average of 25 rabid skunks was reported each year, making skunks the second most commonly identified rabid animal in California. A unique RABVV circulates in California skunks in historically recognized enzootic regions. Roughly two-thirds (160 of 250) of all rabid skunks in the last ten years were reported from five counties in the Sierra Nevada foothills (Amador, El Dorado, and Placer), the central valley (Sacramento), and the central coast (Monterey). Approximately 30 percent of skunks tested from these five counties were confirmed rabid in 2017, compared to just 2.5 percent of skunks tested in the rest of California.

One rabid fox was reported in 2017, compared to 12 foxes in 2016 and a ten-year average of seven foxes (Figure B). Ten or fewer rabid foxes were reported in California each year since 1994, with the exception of 2009 when an epizootic in Humboldt County contributed to 38 of the 41 rabid foxes reported in California that year. It is unclear what factors are necessary to precipitate a rabies epizootic in California foxes. As there is no wild canid RABVV in California, cases of rabies in foxes represent spillover of rabies virus from other species. Potential for spillover is dependent on the population sizes, densities, and range intersection of foxes and at least one species of bat or skunk. The single rabid fox in 2017 was infected with the Brazilian free-tailed bat RABVV. In contrast, RABVVs identified for 10 of 12 rabid foxes in 2016 were a mixture of California skunk (5), California myotis bat (4), and Brazilian free-tailed bat (1). This complex interdependency, coupled with the typically reclusive disposition of foxes, makes fox rabies epizootics difficult to anticipate, recognize, and control.

Rabies was detected in two puppies from the same litter following reported contact with a presumably rabid skunk. California skunk RABVV was identified in the second puppy, verifying a skunk as the source. While virus characterization was not available for the first puppy, it is unlikely that the litter suffered more than one encounter with a rabid animal during the incubation period. Also, it is more likely that both puppies were infected concurrently from the same rabid skunk than that rabies virus was secondarily transmitted from the first puppy to the second. A young immunologically immature puppy will succumb rapidly to rabies encephalopathy and have limited

opportunity for virus to reproduce and be shed in saliva prior to death.

Despite both puppies being infected at the same time, their respective incubations were dramatically different: 1.5 weeks versus 10 weeks. The incubation period for rabies is partly dependent on the anatomic distance from the source of inoculation (ie, bite site) to the central nervous system. For the present cases, the first puppy's putative site of rabies exposure was a wound to the face--tissue rich with cranial nerves only a few centimeters distant from the brain, resulting in a short interval from infection to clinical onset. In contrast, if the second puppy was infected through, for example, an occult wound to a limb (eg, bite to the foot), that difference in inoculation site could contribute to the second puppy's substantially longer incubation.

The mother of the two rabid puppies in 2017 was reported to have been vaccinated against rabies, but there was no documentation of her most recent booster dose. Pregnant dogs that are immunized against rabies can pass antibodies to fetuses transplacentally and to newborns through colostrum. If the female dog was overdue for a booster dose of vaccine, her level of rabies antibodies might have been insufficient to provide the litter protection. Passively acquired maternal antibodies are transient, peaking in puppies approximately two days after whelping and waning over the subsequent 3-6 weeks [Winters 1981]. The 2017 Trinity County litter encountered the presumptively rabid skunk approximately six weeks after whelping, near the theoretical nadir of acquired maternal antibody and before a puppy's innate immune system has fully matured. The American Animal Hospital Association (AAHA) advises that primary administration of noninfectious (ie, killed or recombinant) vaccines to puppies may be accelerated from the standard 12 weeks of age to 6 weeks if the dam was unvaccinated or other failure of passive transfer is suspected to have occurred [Welborn 2011]. However, AAHA recognizes that rabies vaccines represent "a unique class of products" that are governed by state and local laws, that may disallow discretionary deviations from standard rabies vaccine schedules. In California, the minimum age at which a dog may be vaccinated against rabies for purposes of licensure is three months (17 CCR §2606.4 (b)(2)).

References

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.

Welborn LV, DeVries JG, Ford R, et al. 2011 AAHA Canine Vaccination Guidelines. *J Am Anim Hosp Assoc* 2011; 47:1-42.

Winters WD. Time dependent decreases of maternal canine virus antibodies in newborn pups. *Vet Rec* 1981; 108:295-299.

Table A. Reported cases of rabies in animals, California

COUNTY	BAT	SKUNK	CAT	DOG	COYOTE	FOX	HORSE	SHEEP	CATTLE	RACCOON	TOTAL
TOTAL	198	28	1	3	0	1	0	0	0	0	231
Alameda	2										2
-Berkeley City											0
Alpine											0
Amador	1	8		2							11
Butte	4										4
Calaveras		3									3
Colusa											0
Contra Costa	8										8
Del Norte											0
El Dorado	3	9									12
Fresno											0
Glenn	4										4
Humboldt	1										1
Imperial											0
Inyo											0
Kern	4	1									5
Kings	1										1
Lake	2										2
Lassen	1										1
Los Angeles	33										33
-Long Beach City											0
-Pasadena City											0
Madera											0
Marin	16										16
Mariposa		1									1
Mendocino											0
Merced											0
Modoc											0
Mono	1										1
Monterey											0
Napa	1					1					2
Nevada											0
Orange	13										13
Placer	5										5
Plumas											0
Riverside	14										14
Sacramento	5	5	1								11
San Benito											0
San Bernardino	11										11
San Diego	16										16
San Francisco	4										4
San Joaquin	3										3
San Luis Obispo	3										3
San Mateo	3										3
Santa Barbara											0
Santa Clara	5										5
Santa Cruz											0
Shasta											0
Sierra											0
Siskiyou											0
Solano	1										1
Sonoma	3										3
Stanislaus											0
Sutter	6										6
Tehama											0
Trinity				1							1
Tulare	1										1
Tuolumne		1									1
Ventura	7										7
Yolo	13										13
Yuba	3										3

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

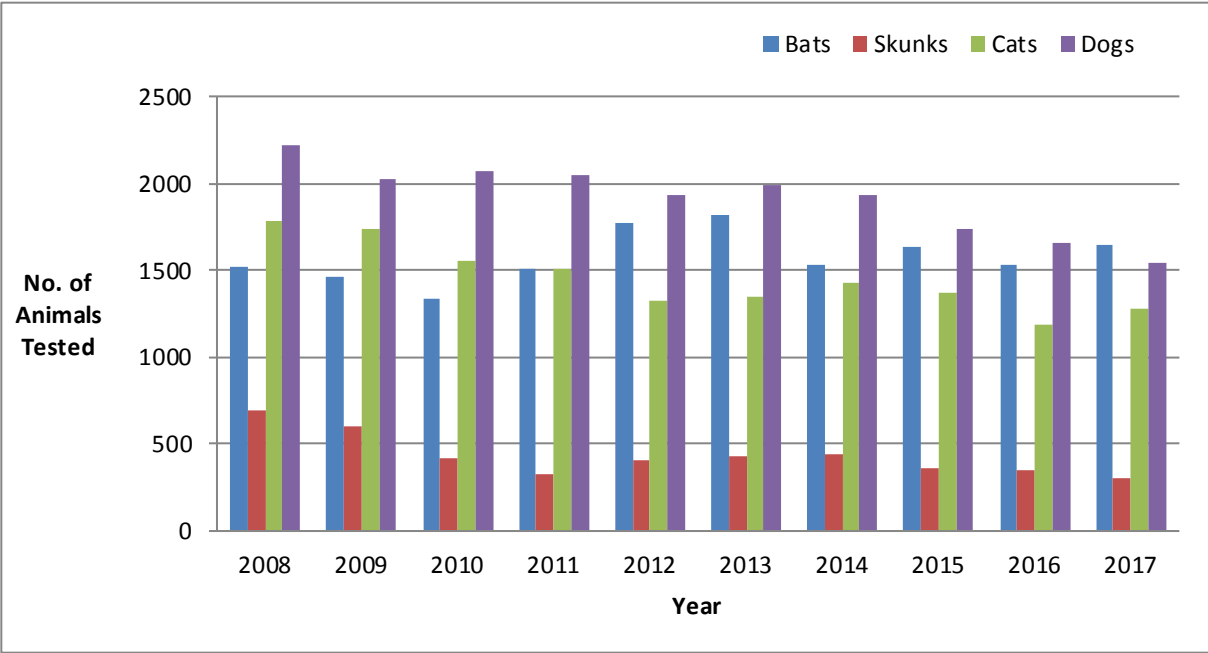


Figure A. Selected wild and domestic animals tested for rabies in California, 2008- 2017.

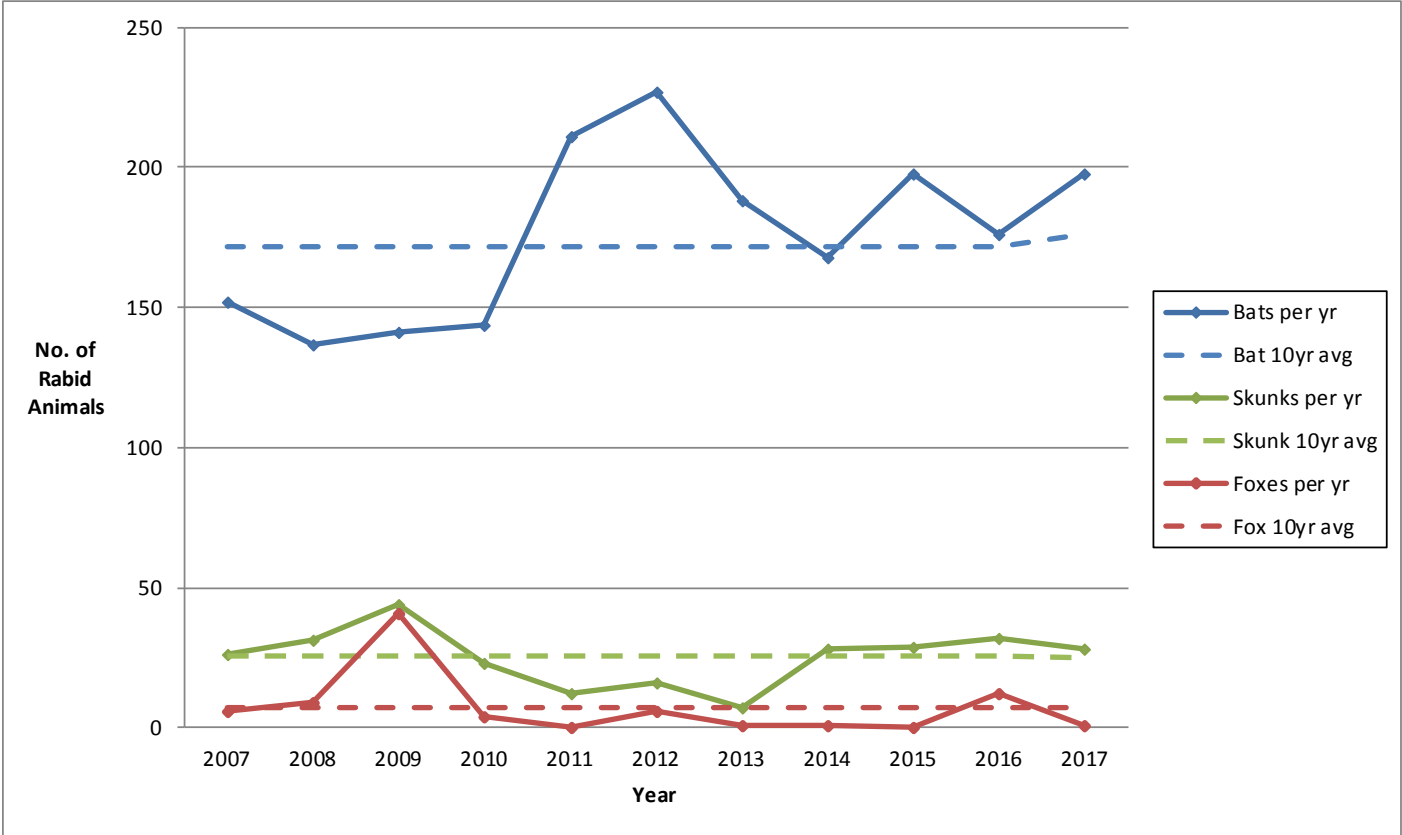


Figure B. Cases of rabies in wild animals in California, 2007-2017.

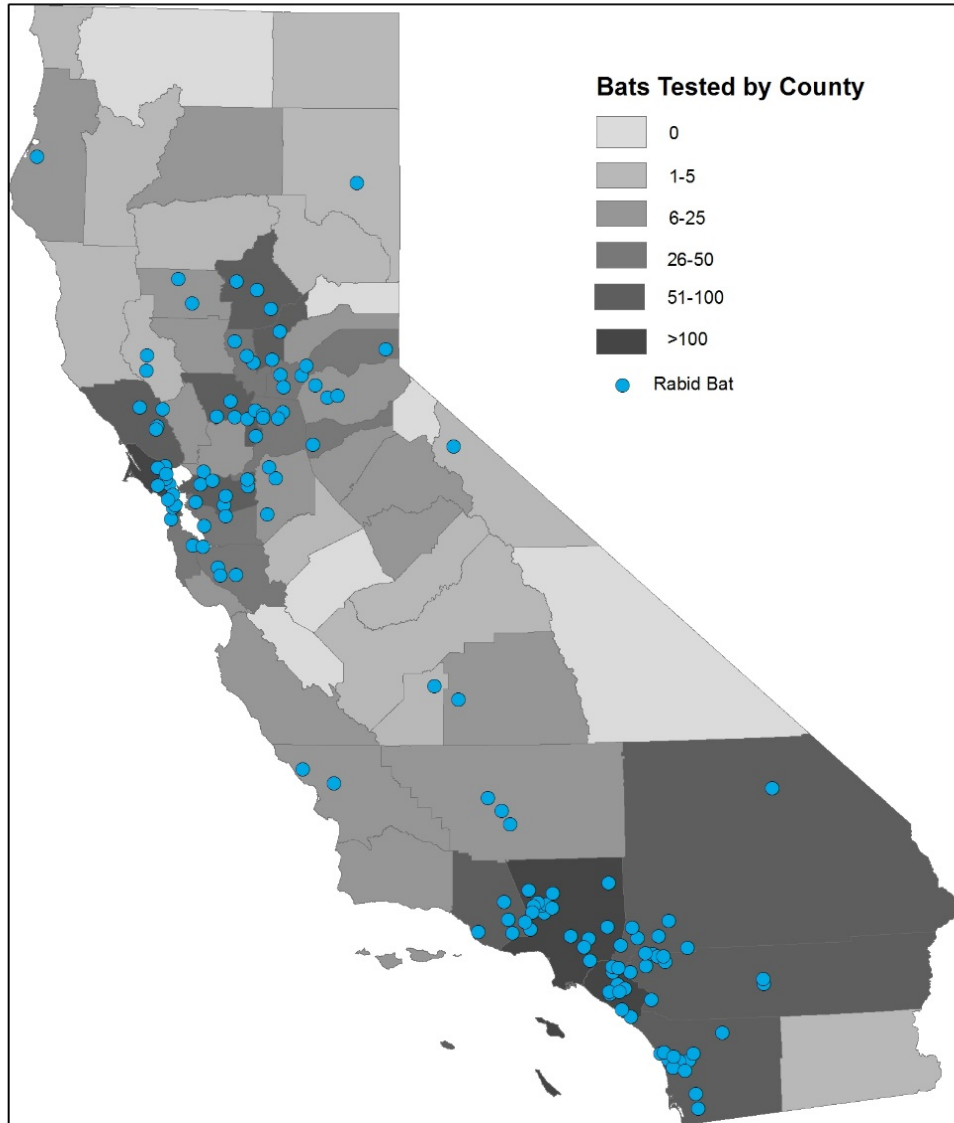


Figure C. Bats tested for rabies by county with positive cases by zip code of collection site (N=198), California, 2017.

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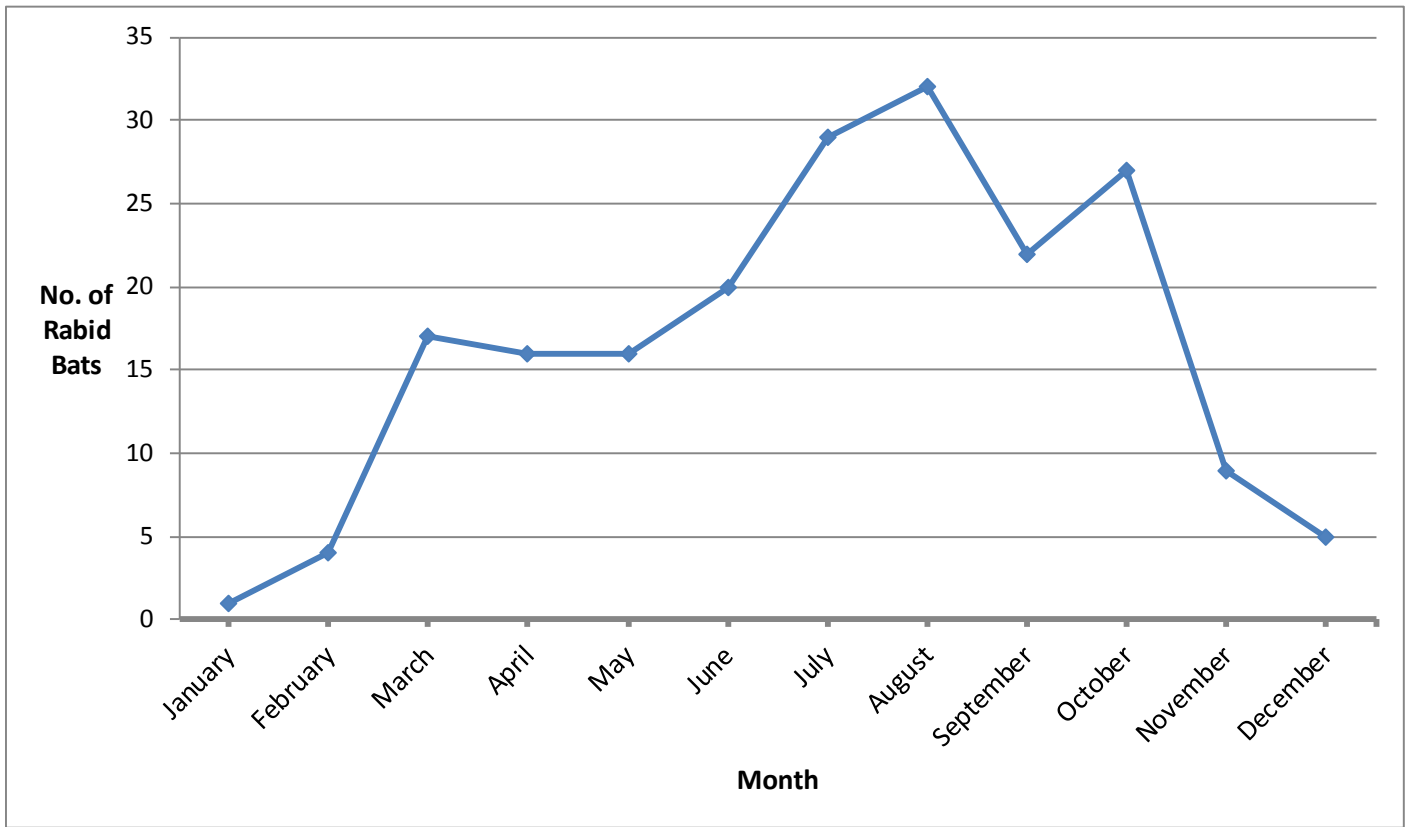


Figure D. Cases of rabies in bats by month of testing, California, 2017.

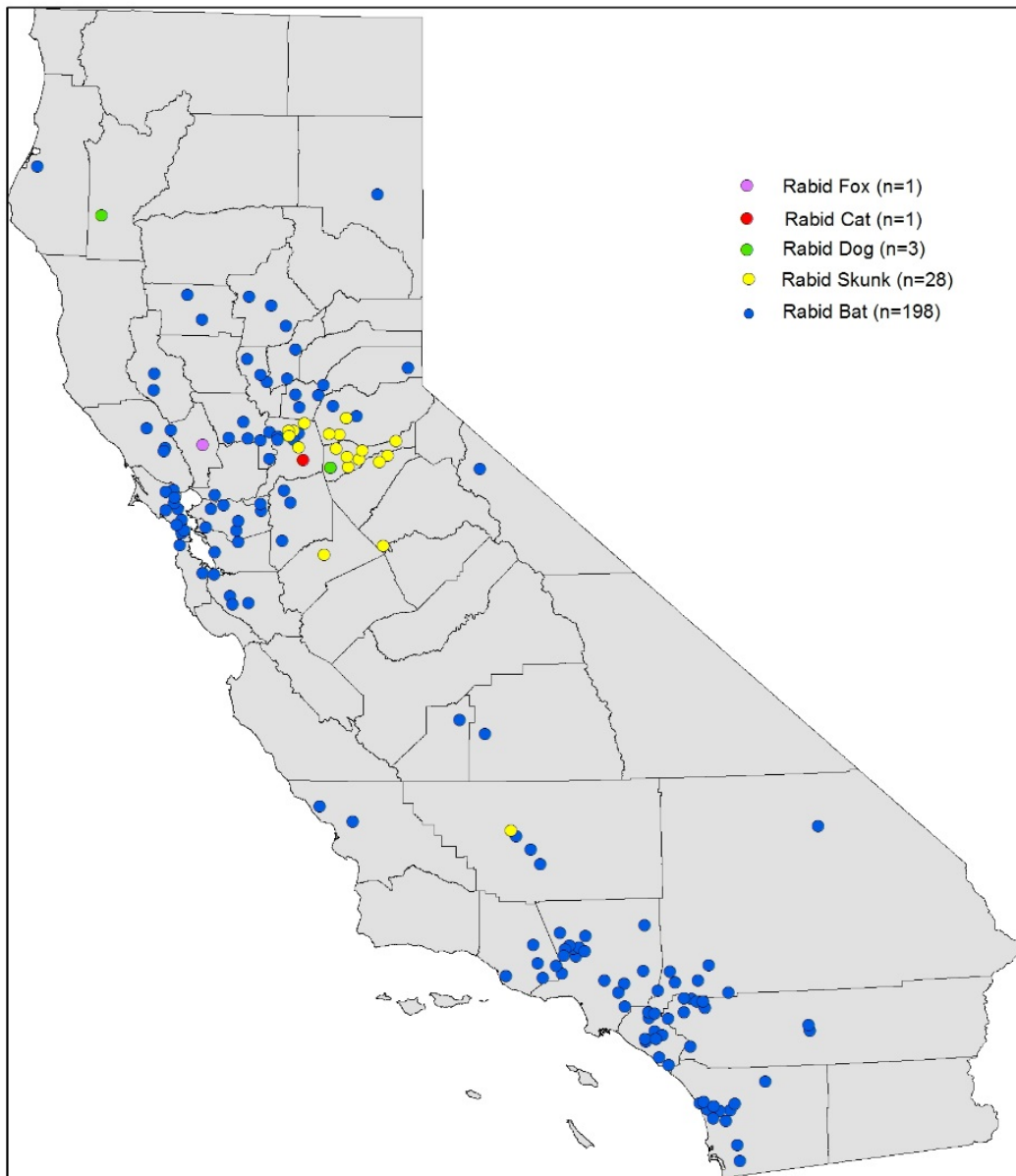


Figure E. Reported cases of rabies in domestic and wild animals by zip code of collection site, California, 2017. Icons may represent one or more rabid animals identified in a given zip code.