

Rabies Surveillance in California Annual Report 2016

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Introduction

Rabies is a severe zoonotic encephalitis caused by a Rhabdovirus of the genus *Lyssavirus*. Following a variable incubation period that can range from one week 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 altered mental status (e.g., hyperactivity and agitation), irritation at the site where the virus was introduced, 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 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 particularly 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 2016, 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 suspect rabies human patients, 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 human and animal rabies cases reported to CDPH in 2016.

Rabies in Animals

In 2016, specimens from 5,355 animals were tested for rabies in California – approximately 15 percent fewer than the annual average of 6,288 specimens tested during the previous ten years, 2006-2015. Of the 56 counties that tested at least one animal for rabies, the number of animals tested per county ranged from 1 to 676.

Rabies was confirmed in 226 animals, similar to the 230 cases confirmed in 2015 and slightly above the annual average of 207 cases in the previous ten years, 2006-2015. One or more rabid animals were identified in 42 counties (Table 1), which reported between 1 and 38 rabid animals each.

Wild Animals

Rabies was diagnosed in 220 wild animals in 2016, accounting for 97 percent of all rabid animals reported to CDPH. Bats (176, 77.9%) were the wild animal most frequently reported rabid, followed by skunks (32, 14.2%) and foxes (12, 5.3%).

Bats

A total of 1,536 bats from 55 counties were tested for rabies in 2016 (Figures A, B). The 176 rabid bats reported in 2016 is comparable to the annual average of 172 reported in the previous ten years, 2006-2015 (Figure C). The greatest number of rabid bats (38) was reported in Los Angeles County, which reported the most rabid bats in eight of the past ten years. The six southern California counties of Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Ventura collectively accounted for 45 percent of all rabid bats detected in California in 2016 (Figure B). Rabid bats were most frequently reported during late summer and early autumn; over half of all rabid bats (98, 56%) were reported in the four months from July through October (Figure D). Information on species was reported for 13 rabid bats: 8 Mexican free-tailed bats (*Tadarida brasiliensis*), 1 big brown bat (*Eptesicus fuscus*), 2 *Myotis* sp., 1 long-eared myotis (*Myotis evotis*), and 1 Canyon bat (*Parastrellus hesperus*).

Skunks

A total of 354 skunks from 37 counties were tested for rabies in 2016, of which 32 from 7 counties were confirmed (Figure E). The 32 rabid skunks in 2016 was greater than the annual average of 26 in the preceding ten years, 2006 - 2015. The greatest number of rabid skunks (12) was reported in El Dorado County. Nearly one third (10, 31%) of the rabid skunks in 2016 were identified in August and September.

Foxes

A total of 51 foxes from 17 counties were tested for rabies in 2016. The 12 rabid foxes confirmed in 2016 is an increase from the annual average of 7 foxes reported in the previous 10 years, 2006–2015 (Figure C).

Domestic Animals

In 2016, 2,876 domestic animals (dogs, cats, horses, cattle, goats, and sheep) were tested for rabies. Rabies was confirmed in three dogs and three cats, notably more than the mean of 1.1 domestic animal rabies cases per year in the previous ten years, 2006-2015.

In February 2016, a two-year-old male English bulldog from Amador County presented to a veterinary clinic with 24 hours lethargy and dysrexia. Upon examination, the dog was noted to have difficulty closing its mouth. The dog was released home without further workup, but returned to the clinic three days later with dropped jaw, excessive salivation, hind limb weakness, and respiratory distress. The dog was euthanized and rabies virus was detected in brain tissue by the El Dorado County Public Health Laboratory. The VRDL identified the virus as consistent with the California skunk RABVV; the owner reported that the dog was sprayed by a skunk approximately one month prior to onset, but no wounds or other signs of injury were noted at that time. The dog's previous owner was located and stated he had administered a rabies vaccine to the dog at home on an unspecified date. Three other animals in the rabid dog's current household—one dog and two cats—were given vaccine boosters and ordered into six-month confinement. A total of 13 individuals who had contact with the dog—including household family members, neighbors, and veterinarian staff—were advised to receive rabies PEP.

In July 2016, an 11-month-old male Rhodesian Ridgeback-mix dog from Humboldt County presented to a veterinary clinic after developing lameness and hypersalivation. While at the clinic, the animal showed signs of aggression and was euthanized. Rabies virus was detected in brain tissue at VRDL. The dog had been vaccinated against rabies approximately 20 months prior to onset, but was overdue for its booster dose. The dog was observed attacking a skunk approximately one month prior to onset. Two other dogs in the household that also had contact with the skunk were re-vaccinated and placed into confinement. Of 13 persons evaluated for possible contact with the dog, rabies PEP was recommended for 6.

In November 2016, an unvaccinated six-month-old male "pitbull-type" dog from Calaveras County presented to a veterinary clinic with history of 24-48 hours of unspecified illness. The dog died while at the veterinary clinic and the body was released to the owners who buried it on their property. Following notification by the veterinarian, Calaveras County Animal Services disinterred the carcass and submitted the brain to San Joaquin County Public Health Laboratory for rabies testing. Infection with rabies virus was confirmed four days after the dog's original presentation. At least 17 other dogs, cats, and livestock shared property with the rabid dog; none had been previously vaccinated against rabies. All animals were euthanized except for three horses that were vaccinated and placed in extended confinement. Nine persons who had contact with the dog—the owner, members of the owner's family, and veterinary staff—were evaluated for possible exposure to rabies virus. Rabies PEP was initiated for six of these persons.

In September, a free-roaming cat of unknown age, sex, and vaccination status from Humboldt County was killed by an individual who had been feeding it and noticed a change in the animal's

behavior. The deceased cat tested positive for rabies at Humboldt County Public Health Laboratory. The rabid cat had shared the location with approximately 20 other cats, 15 of which Animal Control collected and euthanized following the positive rabies result. The individual who killed the cat declined rabies PEP, having completed PEP following a bite from a fox in August 2017.

In November, an unvaccinated, two-year-old spayed cat was taken to a veterinary clinic in Contra Costa County after reportedly biting and scratching two household members, inflicting multiple wounds on their hands and feet. Because the cat lived exclusively indoors, rabies was not suspected and the cat was released home. The next morning, the owner notified the veterinary clinic that the cat had died overnight following sudden onset of paralysis. County animal control staff collected and delivered the cat to Contra Costa Public Health Laboratory for testing, which confirmed rabies. Rabies PEP was recommended to five household members, one family associate, and two veterinary clinic staff.

Also in November, an approximately seven-month-old kitten, acquired as a stray, was presented to a veterinary clinic in Sacramento County due to ataxia. The animal had been spayed and given a rabies vaccine a few days earlier. The veterinarian euthanized the animal and submitted it to the Sacramento County Public Health Laboratory for testing, which confirmed rabies. Rabies PEP was recommended to four family members and four veterinary staff. Other households in the community were apprised of the rabies detection and advised to notify public health officials if they had any contact with the cat, and to ensure that their pets were up to date on their rabies vaccinations.

Rabies in Humans

Rabies was not diagnosed in any California residents in 2016. Four cases of rabies were diagnosed in California residents in the previous ten years (2006- 2015), the most recent in a Contra Costa County resident in 2012.

Rabies in the United States

The U.S. Centers for Disease Control and Prevention (CDC) had not published national rabies data for 2016 at the time this report was prepared.

Discussion

Bats were the most frequently reported rabid animal in California in 2016, 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. Rabies viruses have evolved to include several RABVVs that are efficiently transmitted between bats of a given species. The widespread distribution of innumerable bats sharing intimate roosting space ensures that these well-adapted viruses will perpetuate indefinitely in California bat colonies. As in previous years, most rabid bats in 2016 were detected in the late summer and early autumn—a time when juvenile bats are leaving the roosts for the first time and adult bats are initiating pre-winter migration or search for winter roosts and hibernacula. The proportion of bats that tested positive for rabies in 2016 (176 of 1,536, 11.5%) is slightly lower than that reported in 2015 (13.4%) and comparable to the proportion identified in 2014 (11.6%). Although confined by the limitations of a passive surveillance system, these data suggest that while minor annual fluctuations exist in the dynamics of rabies infection in bats, the prevalence of bat rabies in California remains fairly stable from year to year.

Reported cases of skunk rabies in California have decreased markedly over the past few decades (Figure F). 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, an average of 25 skunk rabies cases are reported each year, making skunks the second most commonly identified rabid animal in California. A unique RABVV circulates in California skunks in certain historically recognized enzootic regions. Roughly three quarters of all rabid skunks in 2016 were reported from three western Sierra Nevada foothill counties: Amador, El Dorado, and Calaveras. Fifty-six percent of skunks from these three counties tested for rabies in 2016 were positive (23 positive of 41 skunks tested), compared to 40 percent in 2014 and 2015. It is unknown if this modest increase in 2016 represents a true higher incidence of rabies in skunks, changes in the selection criteria for skunks submitted for testing, or normal fluctuation within the broad margin of error inherent in a passive surveillance system.

Twelve rabid foxes were reported in 2016, compared to none in 2015 and a ten-year average of seven foxes. (Figure C). 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. In 2016, seven rabid foxes were reported from northern coastal counties (Humboldt, Mendocino, Sonoma) and three rabid foxes from the western Sierra Nevada (Amador, El Dorado, Mariposa counties). Of particular note was detection of rabies in a desert kit fox in eastern Imperial County. This was the first report of rabies in a wild or domestic canid in Imperial County since 1981. Because of the rarity of rabies in wild and domestic canids in Imperial County, and the proximity of the location where the rabid fox was collected to both inter-state and international borders, there was concern that this case might represent the introduction into California of a novel terrestrial (i.e., non-bat-associated) RABVV. Fortunately, the RABVV infecting this kit fox was identified as consistent with Mexican free-tailed bat RABVV—one of the most common RABVVs in California and throughout the United States.

Throughout the history of rabies in North America, a canine RABVV represented the predominant strain in circulation. In the early half of the 20th century, upwards of 1000 cases of rabies were identified each year in California dogs, cats, and livestock. Because domestic dogs were frequently affected, the risk of rabies infection for humans was also several fold greater than it is today. Over 100 California residents were diagnosed with rabies in the first half of the 20th century. In the 1940s and 1950s, development and marketing of effective veterinary rabies vaccines, combined with mandated animal control, vaccination, and licensure laws, successfully slowed and eventually interrupted the transmission of canine RABVV in North America. By the 1970s, the number of rabid dogs in California had declined from several hundred each year to fewer than 10. In 2008, CDC declared the canine RABVV eradicated from the United States. Cases of rabies in domestic and wild canids in California and most of the U.S. now chiefly represent incidental spillover of other terrestrial (raccoon, skunk) or volant (bat) RABVVs.

However, RABVVs adapted to wild canids have been observed in some areas of the United States: a dog-coyote variant in southern Texas along the U.S.-Mexico border, a grey fox variant in central Texas, a different grey fox variant in Arizona, and an Arctic fox variant in Alaska. These wild canine RABVVs present a risk of reintroduction and re-establishment of ongoing rabies transmission among domestic dogs [Amarilla et al. 2017]. In 1994, a coyote

relocated from Texas to Florida resulted in six confirmed and two presumed deaths from rabies among domestic dogs, at least one of which was via secondary transmission from one of the other infected domestic dogs [CDC 1995]. Vigilant monitoring and, in some cases, active control of wild canine rabies is critical to halt incursion of these RABVVs into highly populated areas where humans and domestic dogs reside. An oral rabies vaccination program initiated in Texas in 1995 constrained the spread of coyote and fox rabies and by the 2010s effectively eliminated ongoing domestic transmission within that state [Sidwa et al. 2005; Texas Department of State Health Services].

Three domestic dogs were diagnosed with rabies in California in 2016. One dog had never been vaccinated against rabies, one had received one dose of vaccine but was overdue for its booster, and one had been vaccinated by a previous owner. These three cases underscore not only the need for dogs to be vaccinated against rabies, but also that vaccination strictly adhere to the method, frequency, and type of vaccination specified by state law. For over 60 years, California Health and Safety Code has required all domestic dogs to be vaccinated against rabies. California statute further specifies that such vaccination must be performed with a vaccine approved by CDPH, boosted on a schedule indicated by the vaccine label, and administered by or under the supervision of a licensed veterinarian. Failure to adhere to any one of these requirements can compromise the immunity conferred by the vaccine and leave the animal susceptible to rabies infection.

Three domestic cats were diagnosed with rabies in 2016, one of which was reported to be a strictly indoor cat. Outdoor cats are more vulnerable to physical and microbial threats to their health. Mindful of these risks, the American Veterinary Medical Association adopted policy in 2016 that advocated keeping all owned cats confined to an enriched indoor environment [AVMA 2016]. Nevertheless, restricting cats' movement to an indoor environment does not preclude their potential for contact with wildlife, including animals behaving abnormally due to rabies encephalopathy. For example, a bat that is rabid may be more likely to enter residences and other buildings; similarly, a rabid bat may lack the navigation skills and/or neuromuscular coordination to negotiate its way out of a building. Even an exclusively indoor cat may find irresistible a rabid bat that lies flopping or immobile on the floor. This potential for incursion of rabid animals, particularly bats, into residences, coupled with the natural predatory predisposition and innate curiosity of cats, underscores the risk of rabies for all pet cats. The American Association of Feline Practitioners' Vaccination Advisory Panel recommends vaccination against rabies for all cats that live in rabies-endemic areas [Scherk et al. 2013]. Although all of California is considered endemic for rabies, there is no statewide mandate for vaccination of cats, as exists for dogs, and vaccination is mandated by local ordinance in only 14 California counties.

No human cases of rabies were detected in California in 2016. However, one or more persons experienced bites or had other concerning contact with 31 of the 226 confirmed rabid animals and at least 66 persons were advised to receive rabies PEP as a result of these contacts. A thorough investigation of every confirmed rabid animal by knowledgeable public health officials is critical to ensure that all persons who had contact with the animal are identified, assessed, and counseled regarding their need for rabies PEP.

References

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Table 1. Reported cases of rabies in animals, California, 2016.

COUNTY	BAT	SKUNK	CAT	DOG	COYOTE	FOX	HORSE	SHEEP	CATTLE	RACCOON	TOTAL
TOTAL	176	32	3	3	0	12	0	0	0	0	226
Alameda	2										2
-Berkeley City											0
Alpine											0
Amador	1	8		1		1					11
Butte	6										6
Calaveras		3		1							4
Colusa	1										1
Contra Costa	6		1								7
Del Norte											0
El Dorado	1	12				1					14
Fresno	4										4
Glenn	2										2
Humboldt	2		1	1		4					8
Imperial						1					1
Inyo	1										1
Kern	1										1
Kings											0
Lake											0
Lassen											0
Los Angeles	37										37
-Long Beach City											0
-Pasadena City	1										1
Madera											0
Marin	15										15
Mariposa	2	1				2					5
Mendocino						2					2
Merced											0
Modoc											0
Mono	1										1
Monterey	1	3									4
Napa	1										1
Nevada											0
Orange	12										12
Placer	2										2
Plumas	1										1
Riverside	7										7
Sacramento	2	4	1								7
San Benito											0
San Bernardino	9										9
San Diego	7										7
San Francisco	2										2
San Joaquin		1									1
San Luis Obispo	2										2
San Mateo											0
Santa Barbara	1										1
Santa Clara	3										3
Santa Cruz											0
Shasta											0
Sierra											0
Siskiyou	1										1
Solano	4										4
Sonoma	4					1					5
Stanislaus											0
Sutter	3										3
Tehama	1										1
Trinity	1										1
Tulare	6										6
Tuolumne											0
Ventura	6										6
Yolo	13										13
Yuba	4										4

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

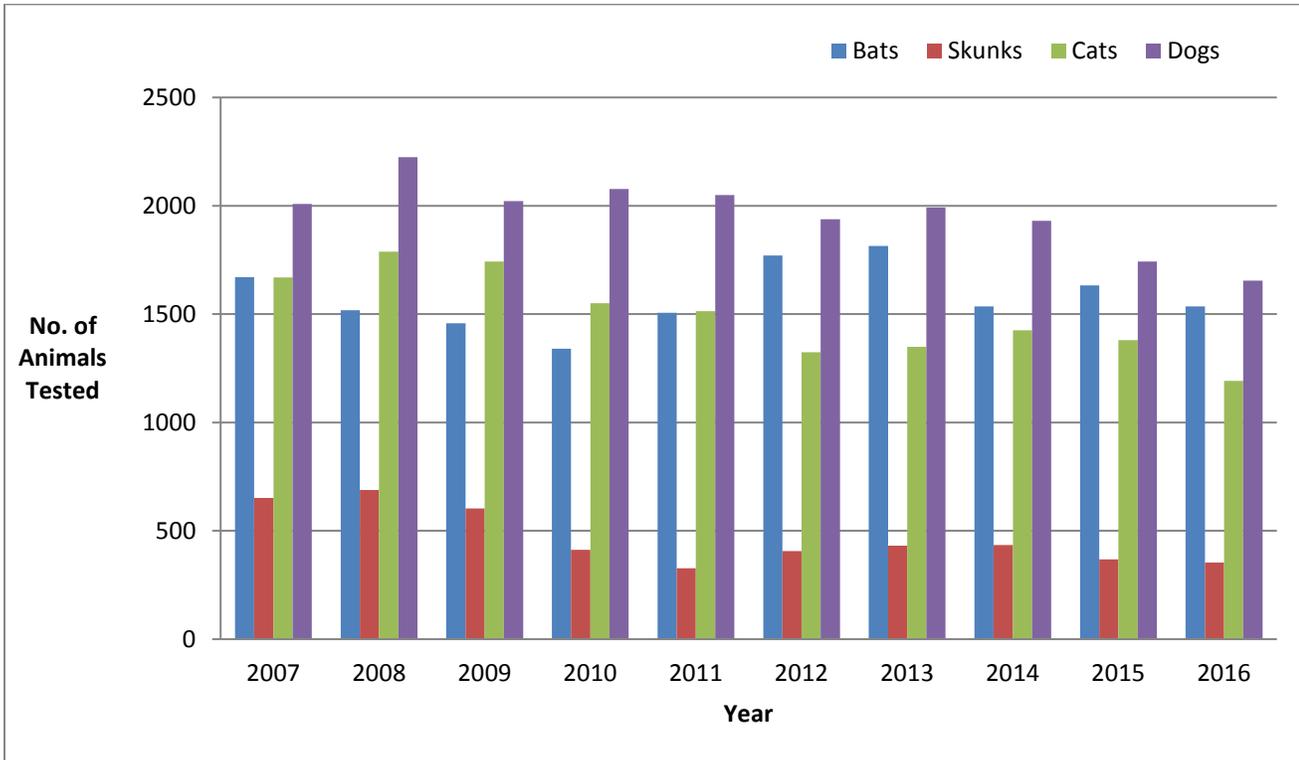


Figure A. Selected wild and domestic animals tested for rabies in California, 2007- 2016.

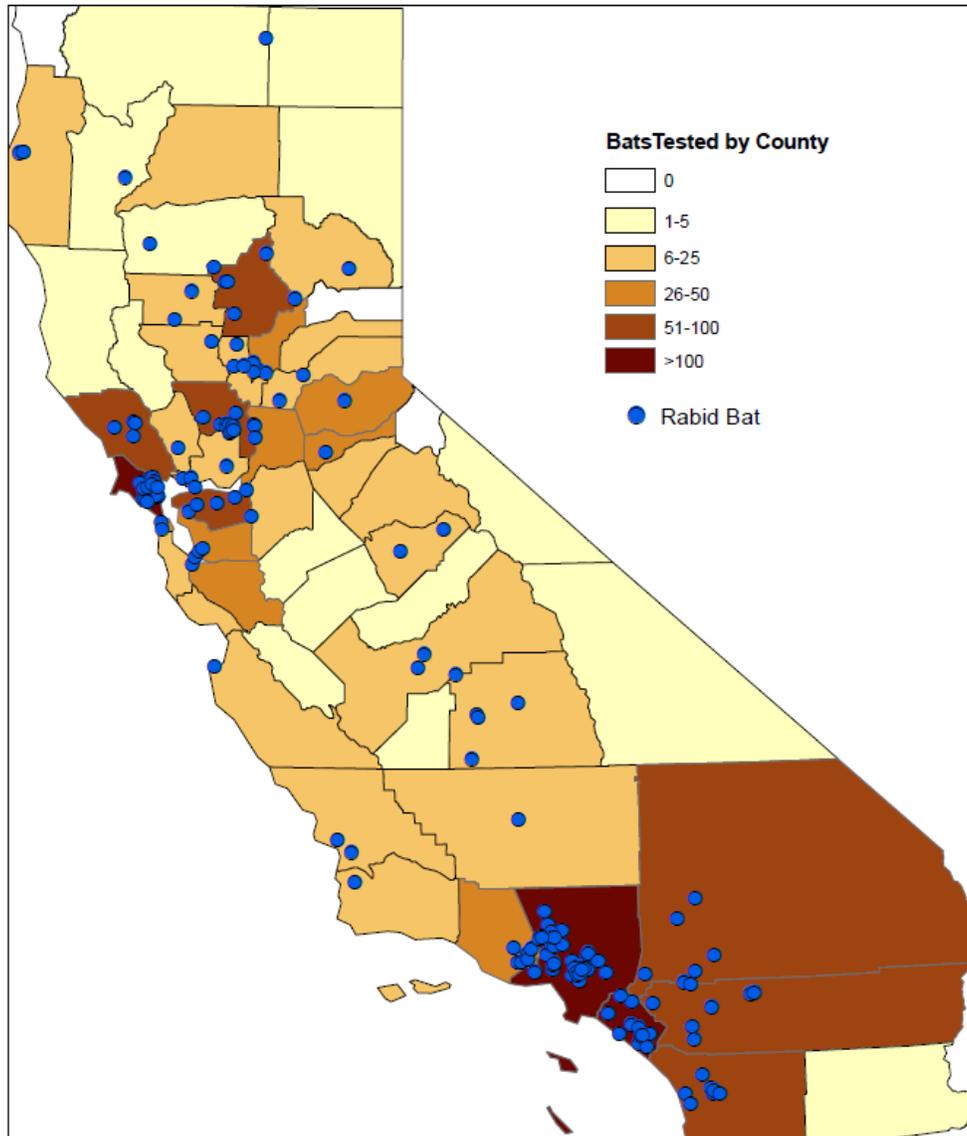


Figure B. Bats tested for rabies by county with positive cases by zip code of collection site (N=176), California, 2016.

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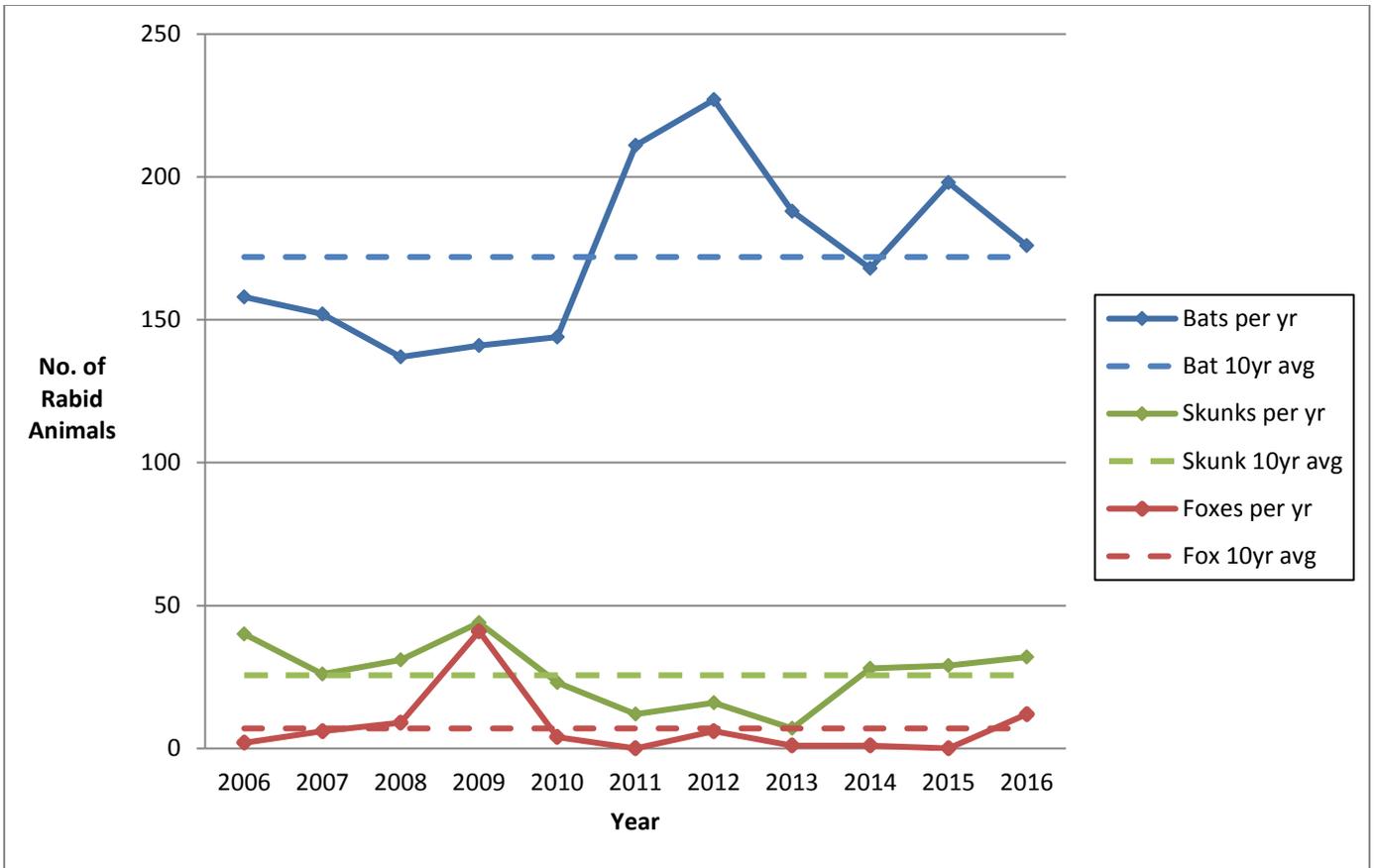


Figure C. Cases of rabies in wild animals in California, 2006-2016.

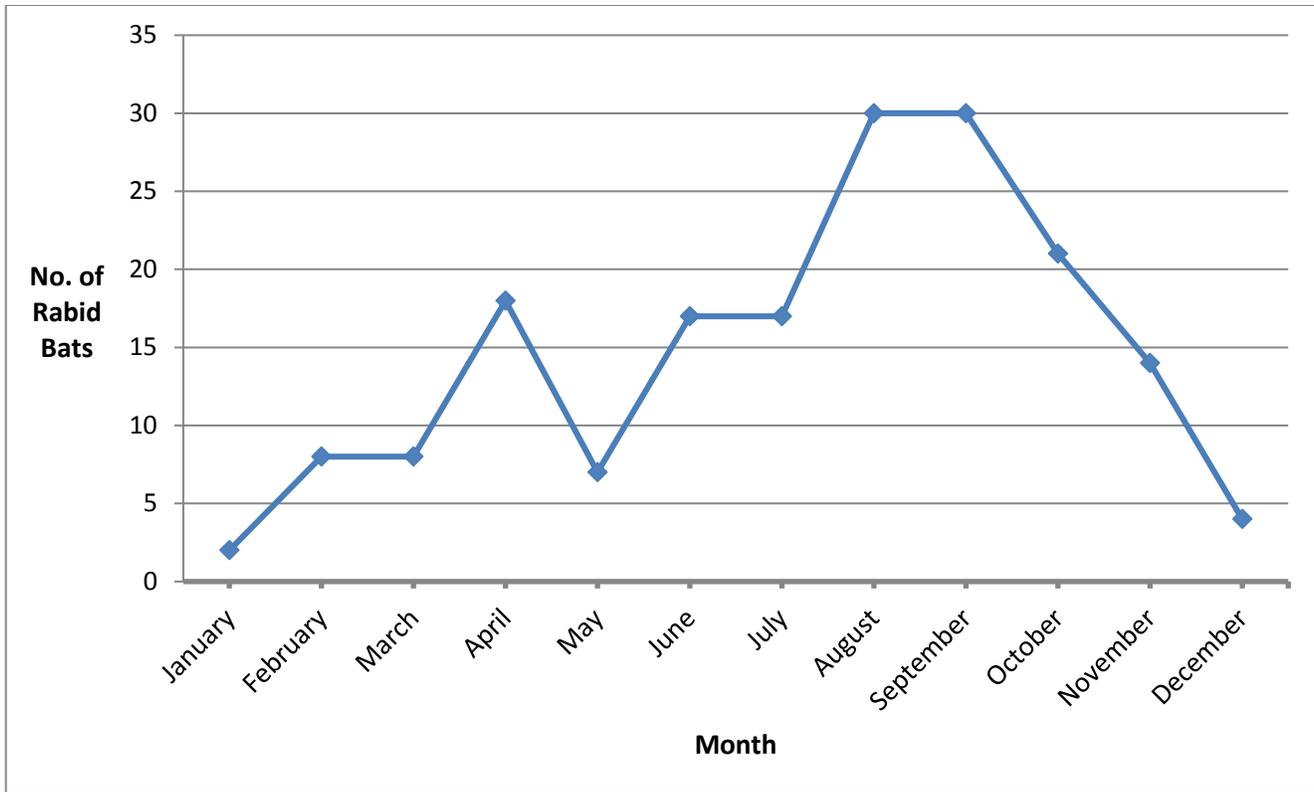


Figure D. Cases of rabies in bats by month of testing, California, 2016.

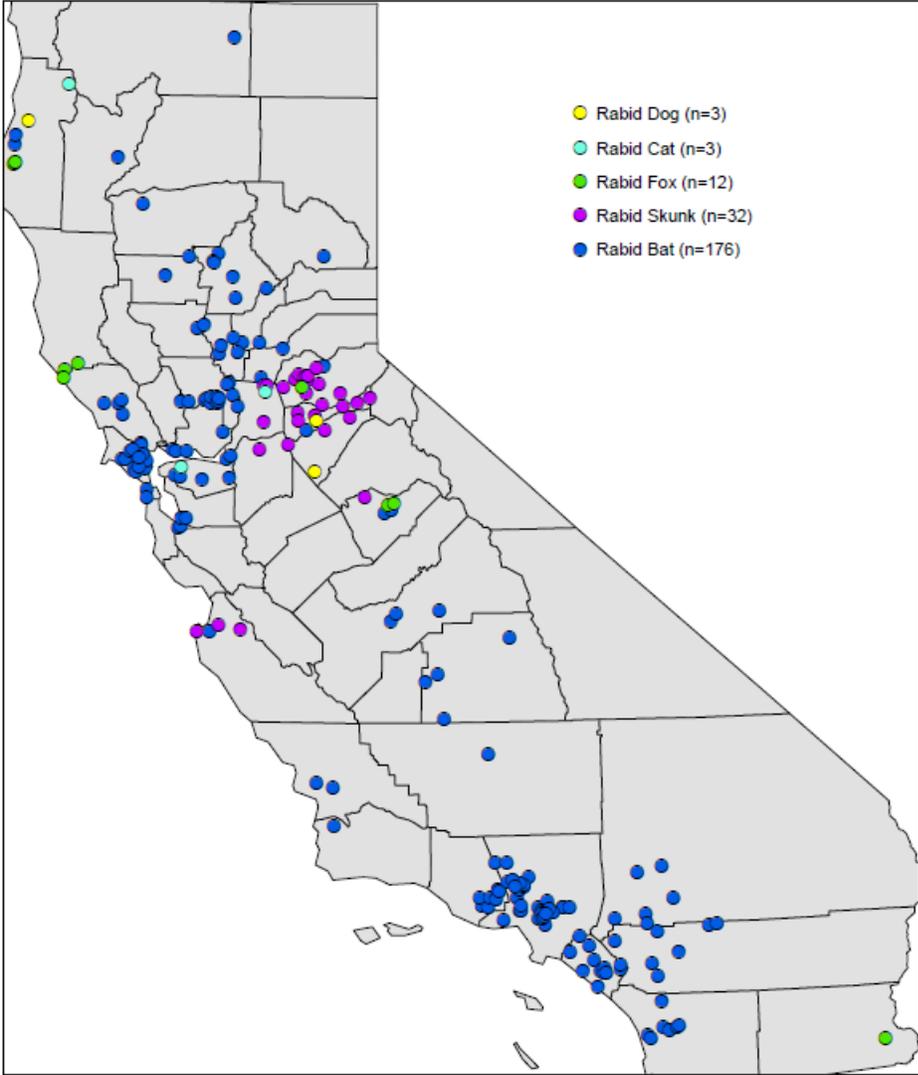


Figure E. Cases of rabies in domestic and wild animals by zip code of collection site, California, 2016

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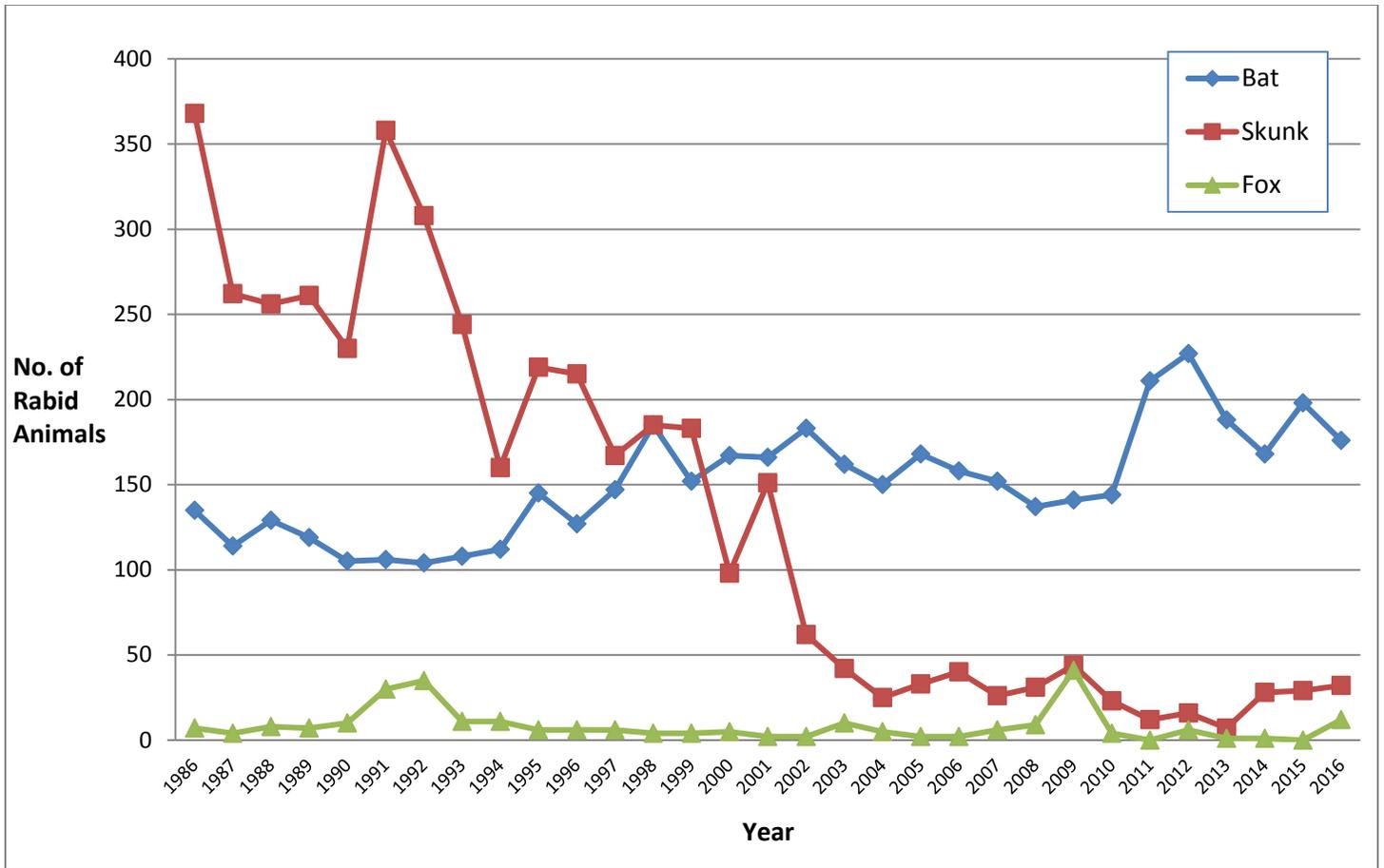


Figure F. Cases of rabies among wild animals in California, 1986-2016.