Rabies Surveillance in California

Annual Report 2013

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California Department of Public Health

December 2014

Introduction

Rabies is a severe encephalitis caused by a Rhabdovirus in 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 easily 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.

Variants of rabies virus are maintained in certain mammalian species, but all rabies viruses are capable of infecting any mammal, including humans. In California, bat variant rabies viruses exist throughout the state, while the California skunk variant is found mostly north of the Tehachapi mountain range. Domestic animals (dogs, cats, and livestock) can be infected with these rabies variants through contact with rabid wildlife but do not typically sustain transmission. 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 each 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,
- Assessing risk of rabies exposure by subjecting biting animals to isolation and observation, or euthanasia and testing,
- Offering recommendations for PEP for exposed humans,
- 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 in either humans or animals as a reportable disease. Health care providers, including physicians and

veterinarians, in knowledge of a case or suspected case of rabies are required to report immediately to the local health officer. Infection with rabies is confirmed in animals by detection of rabies virus antigen, typically in central nervous system tissue, by direct fluorescent antibody assay (DFA) performed by a certified public health microbiologist. Diagnostic testing of suspected rabies in human patients 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 DFA (e.g., nuchal or brain biopsy), polymerase chain reaction (e.g., nuchal biopsy or saliva), or demonstration of rabies-specific antibodies in blood or cerebrospinal fluid by immunofluorescent antibody assay or Rapid Fluorescent Focus Inhibition Test (RFFIT). In 2013, 27 local public health laboratories in California had qualified microbiologists and 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 human rabies 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 2013.

Rabies in Animals

In 2013, specimens from 6084 animals were tested for rabies in California--a seven percent decrease compared to the annual average of 6513 for years 2004-2012. Of the 56 counties that tested at least one animal for rabies, the number of animals tested per county ranged from 1 to 703.

Rabies was confirmed in 198 animals, representing a 21 percent decrease from the 252 cases confirmed in 2012. However, the number of rabies cases in 2013 was comparable to the annual average of 204 cases for the previous nine years, 2004-2012. One or more rabid animals were identified in 34 counties (Table 1), which reported between 1 and 35 rabid animals each.

Wild Animals

Rabies was diagnosed in 196 wild animals in 2013, accounting for 99 percent of all rabid animals reported to CDPH. Bats (188, 96%) were the most frequently reported rabid wild animals, followed by skunks (7, 3.6%). One case of rabies in a fox was reported (<1%).

Bats

A total of 1815 bats from 55 counties were tested for rabies in 2013 (Figures A, B). The 188 rabid bats reported in 2013 were 14 percent above the annual average of 165 reported in 2004-2012 (Figure C). The greatest number of rabid bats was reported in Los Angeles County (35); Los Angeles County reported the greatest number of rabid bats for 7 of 10 years in 2004-2013. The seven southernmost counties—Ventura, Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Imperial--collectively accounted for 48 percent of all rabid bats detected in California in 2013 (Figure B). Rabid bats were

most frequently reported during mid-summer and early autumn; nearly half of all rabid bats (89, 47%) were reported between Week 27 (July 1-7) and Week 39 (September 23-29; Figure D). Information on species was reported only for six rabid bats: 2 California myotis (*Myotis californicus*), 2 *Myotis* sp., and 1 each big brown bat (*Eptesicus fuscus*) and silver-haired bat (*Lasionycteris noctivagans*).

Skunks
A total of 432 skunks from 43 counties were tested for rabies in 2013, of which 7 from six counties were confirmed. (Figure E).

Foxes
A total of 58 foxes from 40 counties were tested for rabies in 2013. Rabies was confirmed in only one fox from Solano County. This case was reported in Week 46 (November 11-17), consistent with observations from 2012 in which half of all rabid foxes (3, 50%) were reported in late autumn between Weeks 45 and 51.

Domestic Animals
In 2013, 3356 domestic animals (dogs, cats, horses, cattle, goats, and camelids) were tested for rabies. One rabid dog and one rabid cat were confirmed, comparable to the mean of 1.2 domestic animal rabies cases per year in 2004-2012.

In January 2013, an unvaccinated 2.5-year-old cat from Sonoma County presented to a local veterinarian with increasing aggressiveness and a low grade fever. The cat was euthanized four days later after biting two of its owners. The Sonoma County Department of Health Services Public Health Laboratory detected rabies virus in the cat's brain; these results were subsequently confirmed at VRDL. Strain typing performed by VRDL identified the rabies virus recovered from the cat as consistent with the California myotis (*Myotis californicus*) bat clade. Rabies PEP was recommended for four persons who had contact with the cat prior to or during its illness. Four other pets (two cats and two dogs) in the home received rabies booster vaccinations and were placed under quarantine.

In August 2013, a 10-month-old dog from San Mateo County presented to a local humane society following 3-4 days of progressive aggression, including one unprovoked attack upon a family member. On presentation, the dog was noted to be lethargic and anorectic with an unusual bark. The dog was euthanized and the brain was submitted to the San Mateo County Public Health Laboratory for rabies testing. Rabies virus was detected by DFA. The VRDL confirmed rabies virus by DFA and characterized the virus as consistent with California skunk variant. The dog was acquired from a breeder in November 2012 and received one vaccine against rabies in January 2013. The dog had minimal opportunity for unsupervised outdoor activity and the owners were unaware of any contact with wildlife. Six household members and two other persons were determined to have sustained bites or to have had possible contact with saliva from the dog during the two weeks prior to its death; all eight persons received rabies PEP. One

other vaccinated dog and one vaccinated cat in the household received rabies booster vaccinations.

Rabies in Humans

Rabies was not diagnosed in any California residents in 2013. Five cases of rabies were diagnosed in California residents from 2004 to 2013, the most recent in a Contra Costa County resident in 2012 (Table 2).

Rabies in the United States

A total of 5865 cases of animal rabies and three cases of human rabies were reported in the U.S. in 2013 [Dyer et al 2014]. Wild animals accounted for 92 percent of all cases; raccoons represented the largest proportion of cases (32.4%), followed by bats (27.2%) and skunks (24.7%). Domestic animals accounted for 8.0 percent of all rabid animals and included 89 dogs and 247 cats. California rabid animals accounted for 3.4 percent of all animal cases in 2013.

Discussion

Bats remained the most commonly identified rabid animal in California in 2013, as they have each year since 2000. The 188 rabid bats in 2013 represented a 17 percent decrease from the 90-year high of 227 observed in 2012. Nevertheless, the total of 582 bats found positive in 2011-2013 remains the highest number observed in any three-year period in California. It is unclear to what degree the observed increase represents a true increased prevalence of rabies in the bat population, an artifact of expanded testing, or variability within the parameters of the surveillance method. Over 1800 bats were tested for rabies in 2013—the greatest number since the year 2000. However, the 10.4 percent that tested positive was slightly less than the 13-14 percent observed in 2011-2012, but comparable to the 9-11 percent observed in 2003-2010. These data suggest that while minor fluctuations in rabies dynamics occur in bat populations, likely attributable to both intrinsic (virus, host) and extrinsic (environment, climate) factors, the prevalence of bat rabies in California, to the extent that it is measurable by the passive surveillance system, remains relatively constant from year to year.

Skunks were the second most commonly identified rabid animal in California in 2013. Rabid skunks were identified in regions of the state historically recognized as enzootic for skunk rabies, including the San Joaquin and Sacramento valleys and the western foothills of the Sierra Nevada. A single rabid skunk was identified in San Bernardino County, an area uncommon for skunk rabies in California. Characterization of the rabies virus by VRDL verified that the San Bernardino skunk was infected with a variant typically found in big brown bats (*Eptesicus fuscus*). The seven rabid skunks in 2013 were less than half the 16 observed in 2012. In fact, the number of rabid skunks was the fewest identified in California for a given year since 1953. Over the past two decades, the annual number of reported rabid skunks has decreased precipitously: from 300-400 cases per year in the 1980s, to fewer than 100 cases in the early 2000s, 12-16 cases in 2011 and 2012, and fewer than 10 in 2013 (Figure F). It is unclear whether this trend

represents a true decrease in incidence or an artifact of reduced sampling; the average number of skunks tested statewide decreased from more than 600 per year in 2004-2009 to fewer than 400 per year in 2010-2013. Nevertheless, the proportion of skunks that tested positive also decreased in this period, from 5.8 percent in 2004-2009, to 4.6 percent in 2010-2012, to 1.6 percent in 2013. A similar decline has been noted nationwide as the number of skunks infected with specific skunk variant rabies virus has decreased more than four-fold since the 1980s [Dyer et al 2013]. The factors driving this decrease in skunk rabies in North America remain unknown.

The single rabid fox reported in 2013 continues the low incidence observed since the mid-1990s. Ten or fewer rabid foxes were reported each of the last 20 years, with the exception of 2009 when an epizootic centered in Humboldt County contributed 38 rabid foxes to the total of 41 reported that year. The single rabid fox in 2013 in Solano County likely represented normal spillover of skunk rabies into the native northern California fox population, rather than a continuation of this epizootic event.

As in 2012, a single cat was diagnosed with rabies in California in 2013. The 2013 cat in Sonoma County was infected with a bat virus variant, as was also the case in 2012. Six rabid bats were also reported in Sonoma County in 2013. The cat's owners did not recall any encounters with wildlife, but because many cats are not confined to their properties of residence, their expanded outdoor ranges can increase opportunities for contact with wildlife. Cats are the domestic animals most frequently diagnosed with rabies in California and the United States; in 2012, 247 rabid cats were reported nationwide, compared to 84 dogs [Dyer 2013]. The natural predatory demeanor and curiosity of cats disposes them to engage in close, repeated contact with wildlife, such as a downed bat, allowing for potential transmission of the rabies virus. Although some local ordinances require cats to be licensed and/or vaccinated against rabies, the absence of a statewide requirement leaves the majority of pet cats unprotected against rabies. For these reasons, 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], which encompasses all of California.

One case of rabies was identified in a domestic dog in 2013. The 10-month-old dog had been vaccinated against rabies approximately seven months prior to illness onset and was not scheduled to receive its next rabies vaccination until January 2014. This is similar to the rabid adult dog detected in California in 2012 which also had been vaccinated approximately seven months prior to onset. No contact with wildlife was observed or suspected for either dog; however, both dogs were likely infected weeks to months after receiving their rabies vaccination. Rabies did not develop in either the bitch or littermates of the 2013 puppy, further suggesting that it was exposed after leaving the breeder. Serum antibody titers stimulated by a single dose of rabies vaccine tend to peak within the initial 2-4 weeks then wane at a rate that varies by age, breed and size, type and brand of vaccine, and other, unknown factors [Aubert 1992, Kennedy et al 2007; Mansfield et al 2004; Minke et al 2009]. In a 10-year review of rabies serum

antibody neutralization test results for dogs relocating from Europe to rabies-free countries (e.g., United Kingdom), 93 percent of dogs showed concentrations equal to or greater than 0.5 IU/ml—the standard threshold for adequate protection in humans—two months after receiving a single vaccine dose [Cliquet et al 2003]. This percentage dropped to 81 percent between two and four months, and to about 75 percent after four months. Dogs that have received a single vaccine dose have unpredictable protection against rabies; reliable long-term immunity is conferred only following vaccine boosters administered at intervals specified in the vaccine label. For this reason, while vaccination significantly reduces the risk of rabies in dogs, rabies should nonetheless remain in the differential diagnosis for dogs that develop a sudden change in behavior or rapidly progressive encephalopathy, particularly young dogs that have received only a single vaccine dose.

No human cases of rabies were detected in California in 2013. However, recognized bites or other suspicious contact with a confirmed rabid animal was reported for 26 of the 198 animal rabies cases, resulting in at least 50 persons undergoing rabies PEP. 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.

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Table 1. Reported cases of rabies in animals, California, 2013.

COUNTY	BAT	SKUNK	CAT	DOG	COYOTE	FOX	HORSE	SHEEP	CATTLE	RACCOON	TOTAL
TOTAL	**188**	**7**	**1**	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**198**
Alameda	4	0	0	0	0	0	0	0	0	0	4
-Berkeley City	1	0	0	0	0	0	0	0	0	0	1
Alpine	0	0	0	0	0	0	0	0	0	0	0
Amador	0	0	0	0	0	0	0	0	0	0	0
Butte	5	0	0	0	0	0	0	0	0	0	5
Calaveras	0	0	0	0	0	0	0	0	0	0	0
Colusa	1	0	0	0	0	0	0	0	0	0	1
Contra Costa	6	0	0	0	0	0	0	0	0	0	6
Del Norte	0	0	0	0	0	0	0	0	0	0	0
El Dorado	3	1	0	0	0	0	0	0	0	0	4
Fresno	3	0	0	0	0	0	0	0	0	0	3
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	1	0	0	0	0	0	0	0	0	0	1
Inyo	0	0	0	0	0	0	0	0	0	0	0
Kern	5	1	0	0	0	0	0	0	0	0	6
Kings	0	0	0	0	0	0	0	0	0	0	0
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	33	0	0	0	0	0	0	0	0	0	33
-Long Beach City	0	0	0	0	0	0	0	0	0	0	0
-Pasadena City	2	0	0	0	0	0	0	0	0	0	2
Madera	0	1	0	0	0	0	0	0	0	0	1
Marin	7	0	0	0	0	0	0	0	0	0	7
Mariposa	0	2	0	0	0	0	0	0	0	0	2
Mendocino	0	0	0	0	0	0	0	0	0	0	0
Merced	0	0	0	0	0	0	0	0	0	0	0
Modoc	0	0	0	0	0	0	0	0	0	0	0
Mono	0	0	0	0	0	0	0	0	0	0	0
Monterey	1	0	0	0	0	0	0	0	0	0	1
Napa	0	0	0	0	0	0	0	0	0	0	0
Nevada	2	0	0	0	0	0	0	0	0	0	2
Orange	13	0	0	0	0	0	0	0	0	0	13
Placer	5	0	0	0	0	0	0	0	0	0	5
Plumas	0	0	0	0	0	0	0	0	0	0	0
Riverside	12	0	0	0	0	0	0	0	0	0	12
Sacramento	5	1	0	0	0	0	0	0	0	0	6
San Benito	0	0	0	0	0	0	0	0	0	0	0
San Bernardino	14	1	0	0	0	0	0	0	0	0	15
San Diego	10	0	0	0	0	0	0	0	0	0	10
San Francisco	2	0	0	0	0	0	0	0	0	0	2
San Joaquin	0	0	0	0	0	0	0	0	0	0	0
San Luis Obispo	0	0	0	0	0	0	0	0	0	0	0
San Mateo	2	0	0	1	0	0	0	0	0	0	3
Santa Barbara	0	0	0	0	0	0	0	0	0	0	0
Santa Clara	7	0	0	0	0	0	0	0	0	0	7
Santa Cruz	0	0	0	0	0	0	0	0	0	0	0
Shasta	1	0	0	0	0	0	0	0	0	0	1
Sierra	0	0	0	0	0	0	0	0	0	0	0
Siskiyou	0	0	0	0	0	0	0	0	0	0	0
Solano	0	0	0	0	0	1	0	0	0	0	1
Sonoma	6	0	1	0	0	0	0	0	0	0	7
Stanislaus	2	0	0	0	0	0	0	0	0	0	2
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	1	0	0	0	0	0	0	0	0	0	1
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	6	0	0	0	0	0	0	0	0	0	6
Yolo	17	0	0	0	0	0	0	0	0	0	17
Yuba	5	0	0	0	0	0	0	0	0	0	5

Table 2. Reported cases of rabies in humans, California, 2004-2013.

Year	Age	Sex	County	Rabies virus variant
2004	22	Male	Los Angeles*	Dog, El Salvador
2006	11	Male	San Joaquin*	Dog, Philippines
2008	16	Male	Santa Barbara*	Bat, Mexican free-tailed
2011	8	Female	Humboldt	Unknown
2012	34	Male	Contra Costa	Bat, Mexican free-tailed

*Imported cases; exposure occurred outside of California

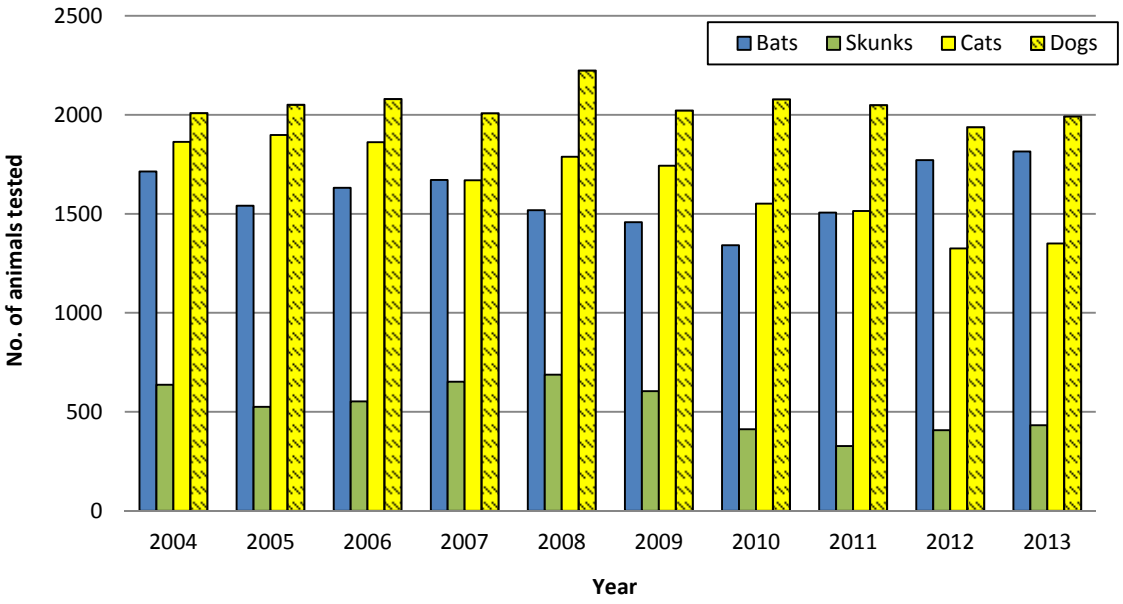

Figure A. Selected wild and domestic animals tested for rabies in California, 2004-2013.

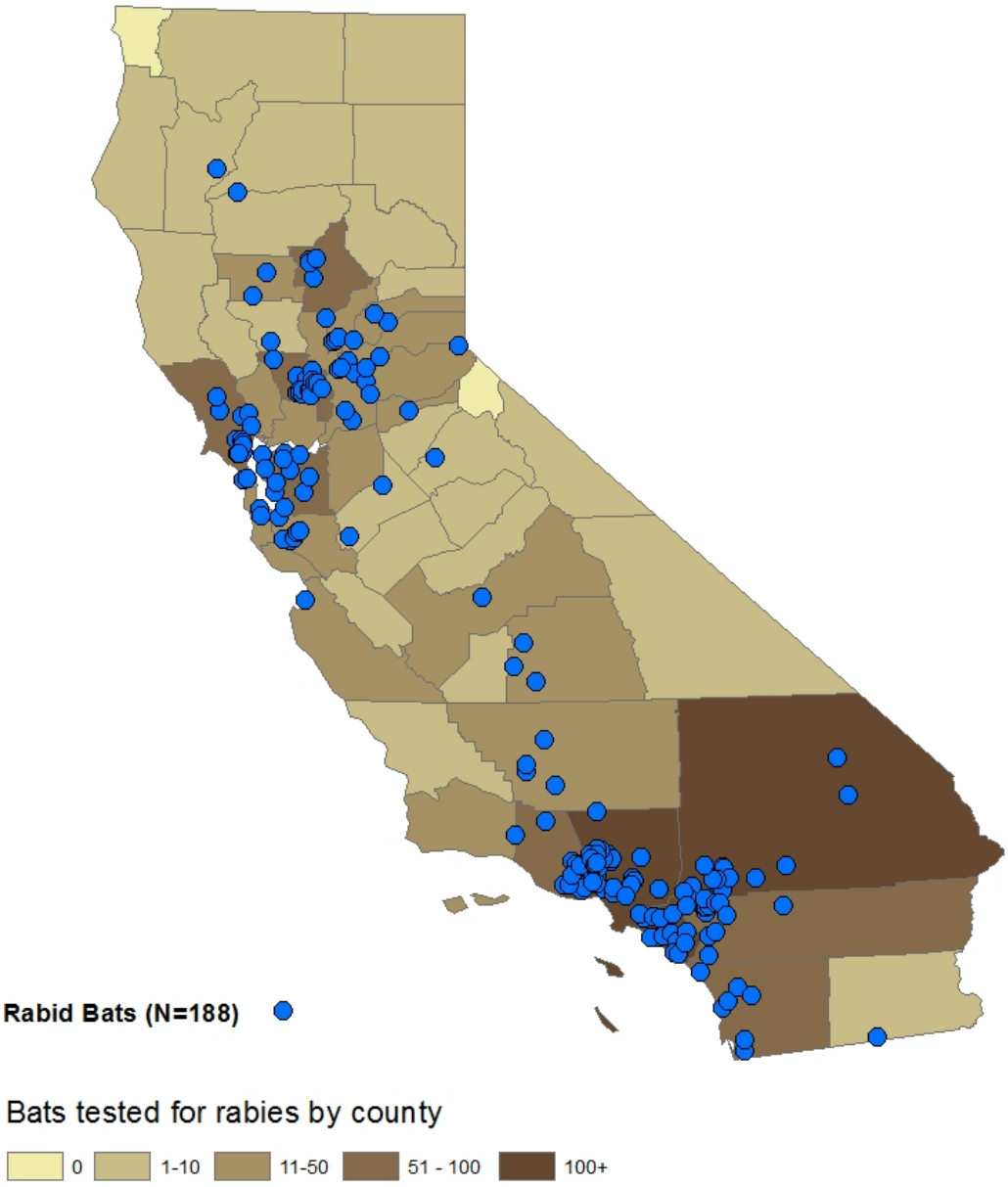

Figure B. Bats tested for rabies by zip code of collection site, California, 2013.

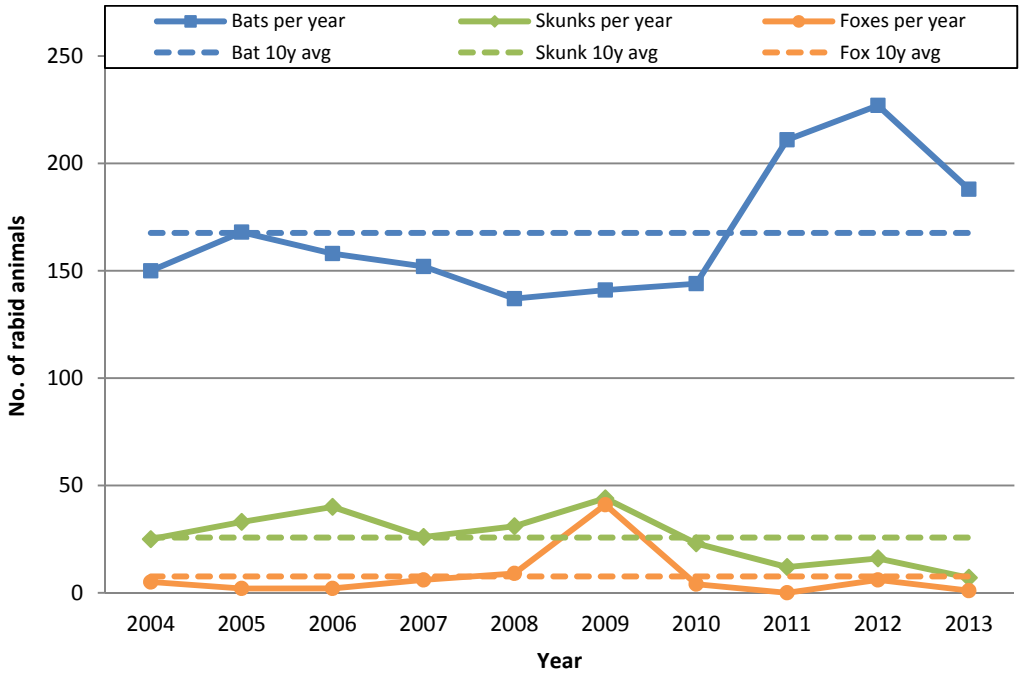

Figure C. Cases of rabies among wildlife in California, 2004-2013.

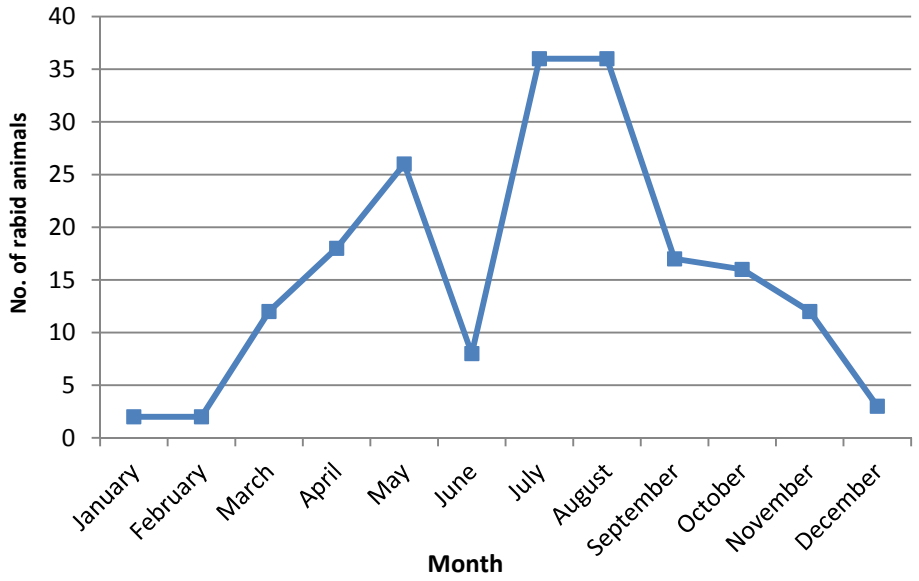

Figure D. Cases of rabies in bats by month of testing, California, 2013.

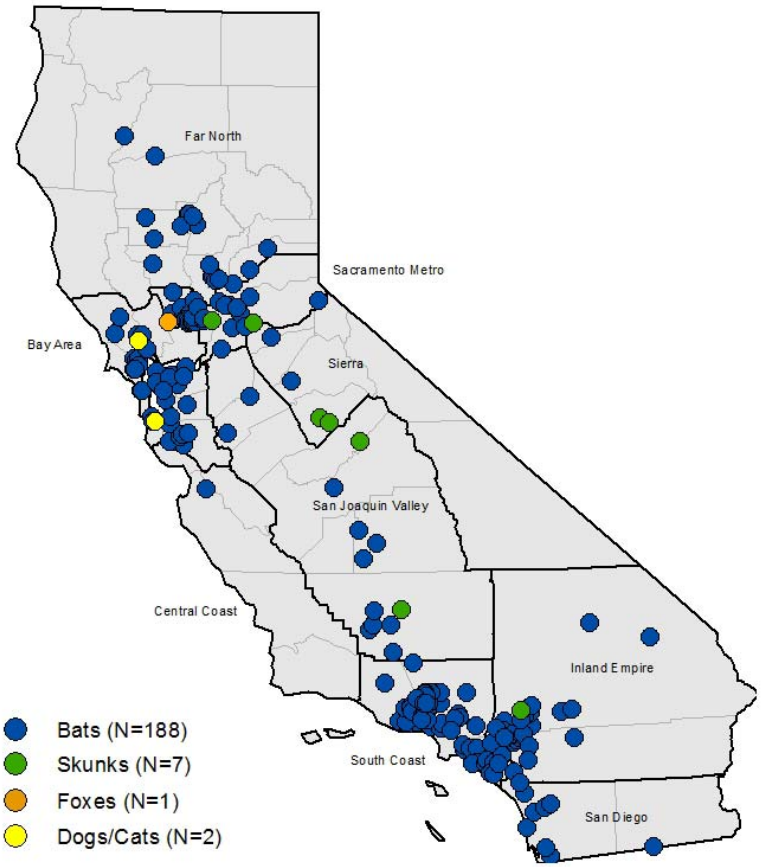

Figure E. Cases of rabies in wild and domestic animals by zip code of collection site, California, 2013.

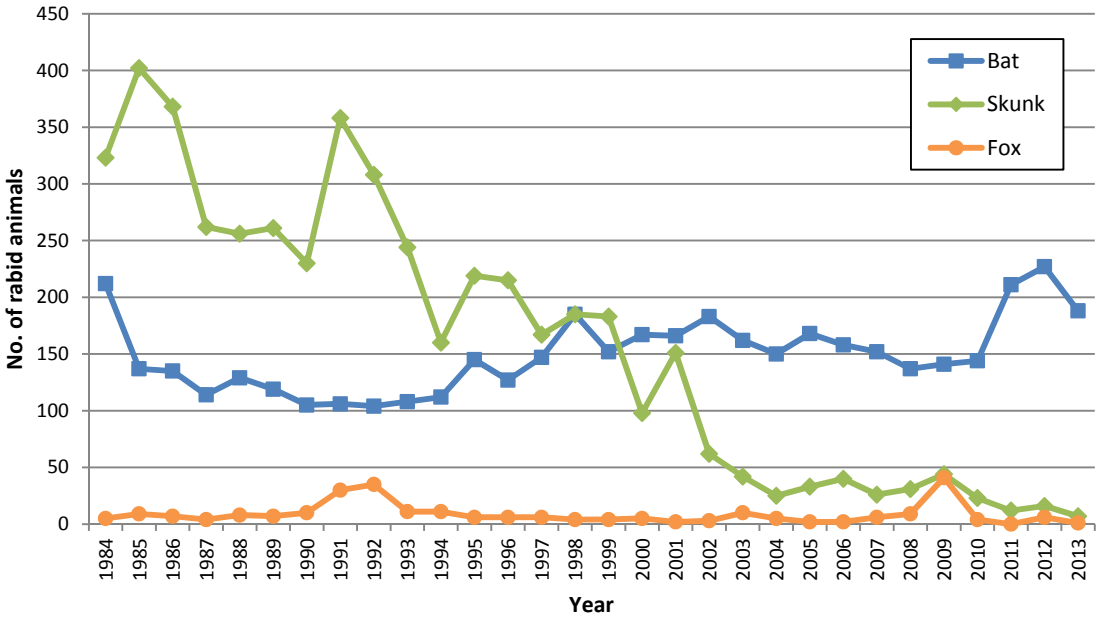

Figure F. Cases of rabies among wildlife in California, 1984-2013.