Rabies Surveillance in California

Annual Report 2015

Veterinary Public Health Section
Infectious Diseases Branch
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California Department of Public Health

October 2016

Introduction

Rabies is a severe zoonotic 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 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,
- 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 that is diagnosed in either humans or animals as a reportable disease. Health care providers, including physicians and veterinarians, in knowledge of a confirmed or suspected case of rabies are required to report immediately to the local health officer. 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 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 in animals by detection of rabies virus antigen, typically in central nervous system tissue, by DFA performed by a certified public health microbiologist. In 2015, 34 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 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 2015.

Rabies in Animals

In 2015, specimens from 5,687 animals were tested for rabies in California – approximately 11 percent fewer than the annual average of 6,425 specimens tested during the previous ten years, 2005-2014. Of the 57 counties that tested at least one animal for rabies, the number of animals tested per county ranged from 1 to 576.

Rabies was confirmed in 230 animals, an increase over both the 200 cases confirmed in 2014 and the annual average of 205 cases in the previous ten years, 2005-2014. One or more rabid animals were identified in 40 counties (Table 1), which reported between 1 and 34 rabid animals each.

Wild Animals

Rabies was diagnosed in 228 wild animals in 2015, accounting for 99 percent of all rabid animals reported to CDPH. Bats (198, 86.8%) were the wild animal most frequently reported rabid, followed by skunks (29, 12.7%) and coyote (1, <1%).

Bats

A total of 1,633 bats from 55 counties were tested for rabies in 2015 (Figures A, B). The 198 rabid bats reported in 2015 exceeded the annual average of 169 reported in the previous ten years, 2005-2014 (Figure C). The greatest number of rabid bats (34) was reported in Los Angeles County; Los Angeles County has reported the most rabid bats for seven of the past ten years. The seven southernmost counties – Ventura, Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Imperial – collectively accounted for 42 percent of all rabid bats detected in California in 2015 (Figure B). Rabid bats were most frequently reported during late summer and early autumn;

approximately half of all rabid bats (94, 47%) were reported in the four months from July through October (Figure D). Information on species was reported for 40 rabid bats: 12 Mexican free-tailed bats (*Tadarida brasiliensis*), 5 hoary bats (*Lasiurus cinereus*), 5 big brown bats (*Eptesicus fuscus*), 5 *Myotis* sp., 2 big free-tailed bats (*Nyctinomops macrotis*), 1 Yuma bat (*Myotis yumanensis*), 1 little brown bat (*Myotis lucifugus*), and 1 Townsend's big-eared bat (*Corynorhinus townsendii*).

Skunks

A total of 364 skunks from eight counties were tested for rabies in 2015, of which 29 from eight counties were confirmed (Figure E). The total of 29 positive skunks in 2015 was comparable to the 28 positive skunks in 2014, despite 129 fewer skunks tested in 2015 (364 in 2015 vs. 435 in 2014). The greatest number of rabid skunks (10) was reported in El Dorado County. Over 60 percent of rabid skunks in 2015 were identified in the autumn and winter, which continued a trend of an increasing proportion of skunk rabies cases identified in autumn and winter (Figure F).

Coyotes

Of 63 coyotes tested for rabies statewide in 2015, rabies was confirmed in one coyote from Calaveras County, which was infected with the California skunk variant of rabies virus (Figure E).

Domestic Animals

In 2015, 3,142 domestic animals (dogs, cats, horses, cattle, goats, and sheep) were tested for rabies. Rabies was confirmed in two cats, consistent with the mean of 1.3 domestic animal rabies cases per year in the previous ten years, 2005-2014.

In June, an unvaccinated four-year-old male neutered domestic shorthair cat was presented to a veterinary clinic in Mendocino County with a history of vomiting, diarrhea, urinary incontinence, and recently scratching and biting the owner. At the clinic, the cat displayed neurological abnormalities and increased aggression. The animal was euthanized and submitted to the Sonoma County Public Health Laboratory where rabies virus was detected by DFA. Typing performed by VRDL identified the rabies virus recovered from the cat as consistent with the California myotis bat (*M. californicus)* variant. Five persons--the cat's owner and four veterinary staff--were evaluated for contact with the cat's potentially infectious tissues or secretions. Two persons—the owner and one veterinary staff—elected to receive rabies PEP. One veterinary staff was determined not to have had exposure and two veterinary staff had been previously immunized against rabies and chose not to receive PEP. One vaccinated cat in the same household that had possible contact with the rabid cat received a booster dose of rabies vaccine. This cat is the first confirmed rabid domestic animal reported in Mendocino County since a rabid dog was confirmed in 1998.

In July, an unvaccinated four-year-old female spayed domestic shorthair cat from Monterey County was brought to a veterinary clinic after repeatedly biting the owner. On examination, the cat was stressed, panting, and vocalizing. It died the following day, and its brain was submitted to the Monterey County Public Health Laboratory for testing. Rabies virus was detected by DFA, and strain typing by VRDL identified the

virus as consistent with the Yuma myotis bat (*M. yumanensis*) variant. The cat's owner was bitten, three veterinary staff had contact with the cat's oral cavity and secretions, and one animal control staff had possible unprotected contact with the cat's brain; all five individuals received rabies PEP. The most recent previous case of rabies in a domestic animal in Monterey County was in a domestic dog in 2012.

Rabies in Humans

Rabies was not diagnosed in any California residents in 2015. Four cases of rabies were diagnosed in California residents in the previous ten years (2005- 2014), the most recent in a Contra Costa County resident in 2012.

Rabies in the United States

A total of 5,508 cases of animal rabies and three cases of human rabies were reported in the U.S. in 2015 [Birhane et al 2017]. Wild animals accounted for 92.4 percent of all cases; bats represented the largest proportion of cases (30.9%), followed by raccoons (29.4%) and skunks (24.8%). Domestic animals accounted for 7.6 percent of all rabid animals and included 67 dogs and 244 cats. California rabid animals accounted for 4.2 percent of all animal cases in 2015. Three cases of human rabies were identified in residents of Massachusetts, Wyoming, and Puerto Rico.

Discussion

Bats were the most frequently reported rabid animal in California in 2015, 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 genetic variants 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 be perpetuated indefinitely in California bat colonies.

As in previous years, most rabid bats 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. In 2015, an unusual number of rabid bats was also observed in the spring; this unseasonal surge was largely reflective of a disproportionate number of rabid bats reported in the San Francisco Bay Area. Of the total 40 rabid bats detected in the counties of Alameda, Contra Costa, San Francisco, San Mateo, Santa Clara, and Solano in 2015, 24 (60%) were identified in the three months of March, April, and May. Both the raw number of rabid bats and the proportion for the year were appreciably greater in March-May of 2015 than in the same periods in 2013 (5 of 22, 22%) and 2014 (9 of 25, 36%). The 24 rabid bats represented at least five different species and were collected from 13 different cities, indicating that the observed increase was likely not indicative of an epizootic affecting a single or related colonies. Local publicity regarding bats and rabies through print and broadcast media may have raised awareness of the associated health risks and motivated residents to report bats observed in their communities: 298 bats from the six Bay Area counties were tested in 2015, compared to 215 tested in 2014. Furthermore, the proportion of bats that tested positive in 2015 (13.4%) was only slightly greater than that in 2014 (11.6%), also

suggesting that the observed peak was at least partially attributable to enhanced detection and not a significant underlying epizootic.

The incidence of skunk rabies in California has decreased markedly over the past few decades (Figure G). In 1985, there were 402 reported cases of skunk rabies, but the number of cases dropped to below 100 in 2000, and to less than 50 by 2003. Nonetheless, skunks remained the second most commonly identified rabid animal in California in 2015. A unique skunk variant of rabies virus circulates in populations of skunks in certain regions of California. In 2015, rabid skunks were identified in parts of the state historically recognized as enzootic for skunk rabies, with the western Sierra Nevada foothills (Amador, El Dorado, and Placer counties) accounting for almost two thirds (62%) of all reports.

Rabies incidence in wild animals in temperate regions often follows certain seasonal patterns. For example, skunks infected with the south central U.S. skunk variant are more frequently reported in winter and early spring (Clark et al. 2015, Hass and Dragoo 2006, Heidt et al. 1982, Pool and Hacker 1982). The California skunk variant has historically described a less pronounced seasonal pattern: rabid skunks were identified throughout the year, with a slight majority in spring and summer (April – September). However, beginning in 2012, the proportion of rabid skunks identified in spring/summer has declined; in 2015, only a third of rabid skunks were observed in this six-month period. The hot, dry summers experienced in California in recent years may have directly impacted the survivability of skunks, leading to increased mortalities due to non-infectious causes. Future surveillance of rabies in California skunks will be necessary to determine if the apparent trend represents a true seasonal shift in skunk rabies epizootiology or reflects normal fluctuations in the ongoing enzootic cycle. Conversely, less hospitable environmental conditions might also partially explain increased detection of rabies in skunks. Skunks from El Dorado County that were submitted for rabies testing numbered 31 in 2015 and 35 in 2014, as compared to only 5 in 2013. This rise over the past two years may be due in part to an influx of skunks into developed areas. As proposed in the 2014 Rabies Annual Report (CDPH 2016), altered precipitation patterns and decreased abundance of natural water sources may compel skunks to expand their range into developed, residential areas in search of water, leading to greater opportunity for a rabid animal to be observed, collected, and tested. If the peri-residential infiltration of skunk rabies continues, active control measures may become critical to protect the public.

Significant increases in the activity of terrestrial rabies in a defined area, or threatened expansion into new or heavily populated regions, can demand attempts to supplement standard personal protective measures with direct control of virus transmission among reservoir species. Development and strategic deployment of oral rabies vaccines (ORV) is one proven method for modulating rabies activity in some carnivore populations. Following the translocation of rabid raccoons from Florida into mid-Atlantic states in the late 1970s, ORV campaigns begun in the mid 1990s reduced rabies activity in focused areas (Horman et al. 2012) and contained the epizootic's westward expansion. ORV campaigns in Texas were successful in eliminating or halting the spread of unique canine variant rabies viruses in coyotes and gray foxes (Fearneyhough et al. 1998; Sidwa et al. 2005). The only currently

licensed oral rabies vaccine in the U.S., Raboral V-RG® (Merial Inc., Duluth, GA), has been packaged into various bait delivery systems designed to appeal to the dietary preferences, size, and other characteristics of these target species. Skunks have to date remained refractory to immunization with all Raboral V-RG® bait-vaccine packages. In 2011, the U.S. Department of Agriculture's (USDA) Animal and Plant Health Inspection Service (APHIS) initiated a series of field trials to evaluate the safety and efficacy of ONRAB® (Artemis Technologies, Guelph, Ontario, Canada), a human adenovirus recombinant ORV used successively in Canada since the mid 1980s (USDA 2016). Under controlled conditions, ONRAB® bait packets demonstrated high consumption acceptability, produced moderate detectable rabies antibody, and conferred broad protection against rabies virus challenge among experimental skunks (Brown et al. 2014, Johnson et al. 2016). However, while USDA ONRAB® field trials effected seropositivity among raccoons that was comparable or superior to that observed in Raboral V- RG® campaigns, uptake by skunks in the wild was low when ONRAB® was deployed at the same density and range used for raccoons. Although significant practical and financial obstacles would remain, field demonstration of an effective ORV for skunks may permit consideration of an ORV campaign as a feasible adjunct to traditional methodologies for control of skunk rabies in California, should continued expansion in the western Sierra Nevada counties or elsewhere occur (Sterner et al. 2008).

The finding of a single rabid coyote and no rabid foxes in 2015 is consistent with the low incidence observed in wild canids for the past 30 years. Only 8 rabid coyotes were identified in California from 1986 to 2015, compared to 247 rabid foxes. Wild canids are more often infected with the skunk rabies variant than the bat variant. Foxes may be more likely than coyotes to be exposed to rabies from skunks due to similarity in their ecological niches, including overlapping habitats and home ranges. Both gray foxes and skunks frequently take cover in natural cavities, abandoned burrows, and under buildings, whereas coyotes prefer brushy strands of vegetation and occasionally subterranean recesses (Zeiner 1988). Gray foxes and skunks are also known to take cover above ground in trees, a habit not observed in coyotes (Walker et al. 1964). Territoriality is more pronounced in gray foxes and skunks than in coyotes; as such, encounters between foxes and skunks may be more aggressive and result in injuries that provide greater opportunity for virus transmission (Zeiner 1998).

Two domestic cats were diagnosed with rabies in 2015, in Mendocino and Monterey counties. Cats are the domestic animal most frequently diagnosed with rabies in California and the rest of the United States. In 2014, 272 rabid cats were reported nationwide (61.1% of cases among domestic animals), compared to 59 dogs (33.7% of domestic animal cases; Monroe et al. 2016). 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 rabies virus. The owners of the two rabid cats in California in 2015 did not specifically recall any encounters with wildlife, but one cat spent nine hours outside every day while the owner was away at work and the other cat lived primarily outdoors, coming inside only for food. Recognizing that "[f]ree- roaming [behavior] increases the cat's exposure to infectious,

parasitic, and zoonotic disease," the American Veterinary Medical Association adopted policy in 2016 that advocated keeping all owned cats confined to an enriched indoor environment (AVMA 2016). In addition, the American Association of Feline Practitioners' Vaccination Advisory Panel recommends vaccination against rabies for all cats that live in rabies-endemic areas, which includes all of California (Scherk et al. 2013).

Both rabid cats identified in 2015 were infected with bat virus variants, as were the four feline cases in 2012-2014 in California. A single rabid bat was noted in Mendocino County four months after the cat was detected, and no rabid bats were reported in Monterey County in all of 2015. These cases illustrate the limitations of data obtained from a passive surveillance system, including a low sensitivity for detecting infection and disease in populations of wild animals. Rabies surveillance data can represent both an over-estimate (i.e., rabid bats are more likely than healthy bats to be collected and tested) and an under-estimate (i.e., the number of bats tested represents an infinitesimal proportion of the millions of bats in California) of rabies prevalence in wild animals at any given time. Rabies is known to circulate in bat and skunk populations throughout California, and the absence of positive tested individuals in a particular area or within a given period should not be interpreted as indicative of negligible risk of transmission to non-reservoir species, such as dogs, cats, or people.

No human cases of rabies were detected in California in 2015. However, one or more persons experienced bites or other concerning contact with each of 32 of the 230 confirmed rabid animals and at least 48 persons underwent rabies post- exposure prophylaxis (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, 2015.

COUNTY	BAT	SKUNK	CAT	DOG	COYOTE	FOX	HORSE	SHEEP	CATTLE	RACCOON	TOTAL
TOTAL	198	29	2	0	1	0	0	0	0	0	230
Alameda	13	0	0	0	0	0	0	0	0	0	13
-Berkeley City	0	0	0	0	0	0	0	0	0	0	0
Alpine	0	0	0	0	0	0	0	0	0	0	0
Amador	0	3	0	0	0	0	0	0	0	0	3
Butte	12	0	0	0	0	0	0	0	0	0	12
Calaveras	1	3	0	0	1	0	0	0	0	0	5
Colusa	2	0	0	0	0	0	0	0	0	0	2
Contra Costa	7	0	0	0	0	0	0	0	0	0	7
Del Norte	0	0	0	0	0	0	0	0	0	0	0
El Dorado	2	10	0	0	0	0	0	0	0	0	12
Fresno	1	0	0	0	0	0	0	0	0	0	1
Glenn	2	0	0	0	0	0	0	0	0	0	2
Humboldt	0	1	0	0	0	0	0	0	0	0	1
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	0	0	0	0	0	0	0	0	0	0	0
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	34	0	0	0	0	0	0	0	0	0	34
-Long Beach City	0	0	0	0	0	0	0	0	0	0	0
-Pasadena City	0	0	0	0	0	0	0	0	0	0	0
Madera	0	0	0	0	0	0	0	0	0	0	0
Marin	3	0	0	0	0	0	0	0	0	0	3
Mariposa	0	0	0	0	0	0	0	0	0	0	0
Mendocino	1	0	1	0	0	0	0	0	0	0	2
Merced	2	0	0	0	0	0	0	0	0	0	2
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	0	3	1	0	0	0	0	0	0	0	4
Napa	1	0	0	0	0	0	0	0	0	0	1
Nevada	0	0	0	0	0	0	0	0	0	0	0
Orange	11	0	0	0	0	0	0	0	0	0	11
Placer	2	5	0	0	0	0	0	0	0	0	7
Plumas	0	0	0	0	0	0	0	0	0	0	0
Riverside	16	0	0	0	0	0	0	0	0	0	16
Sacramento	9	3	0	0	0	0	0	0	0	0	12
San Benito	0	0	0	0	0	0	0	0	0	0	0
San Bernardino	8	0	0	0	0	0	0	0	0	0	8
San Diego	6	0	0	0	0	0	0	0	0	0	6
San Francisco	3	0	0	0	0	0	0	0	0	0	3
San Joaquin	2	1	0	0	0	0	0	0	0	0	3
San Luis Obispo	1	0	0	0	0	0	0	0	0	0	1
San Mateo	3	0	0	0	0	0	0	0	0	0	3
Santa Barbara	1	0	0	0	0	0	0	0	0	0	1
Santa Clara	10	0	0	0	0	0	0	0	0	0	10
Santa Cruz	1	0	0	0	0	0	0	0	0	0	1
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	4	0	0	0	0	0	0	0	0	0	4
Sonoma	5	0	0	0	0	0	0	0	0	0	5
Stanislaus	3	0	0	0	0	0	0	0	0	0	3
Sutter	3	0	0	0	0	0	0	0	0	0	3
Tehama	1	0	0	0	0	0	0	0	0	0	1
Trinity	0	0	0	0	0	0	0	0	0	0	0
Tulare	6	0	0	0	0	0	0	0	0	0	6
Tuolumne	0	0	0	0	0	0	0	0	0	0	0
Ventura	7	0	0	0	0	0	0	0	0	0	7
Yolo	7	0	0	0	0	0	0	0	0	0	7
Yuba	6	0	0	0	0	0	0	0	0	0	6

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

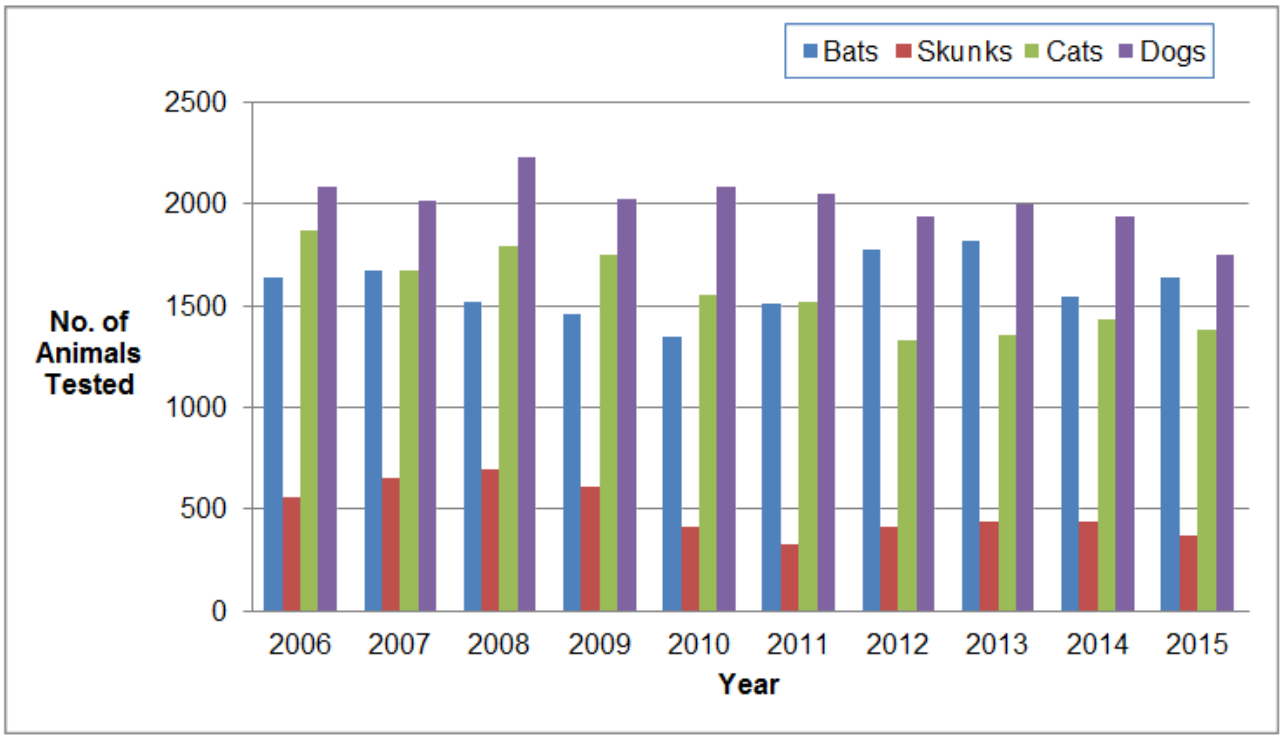

Figure A. Selected wild and domestic animals tested for rabies in California, 2006- 2015.

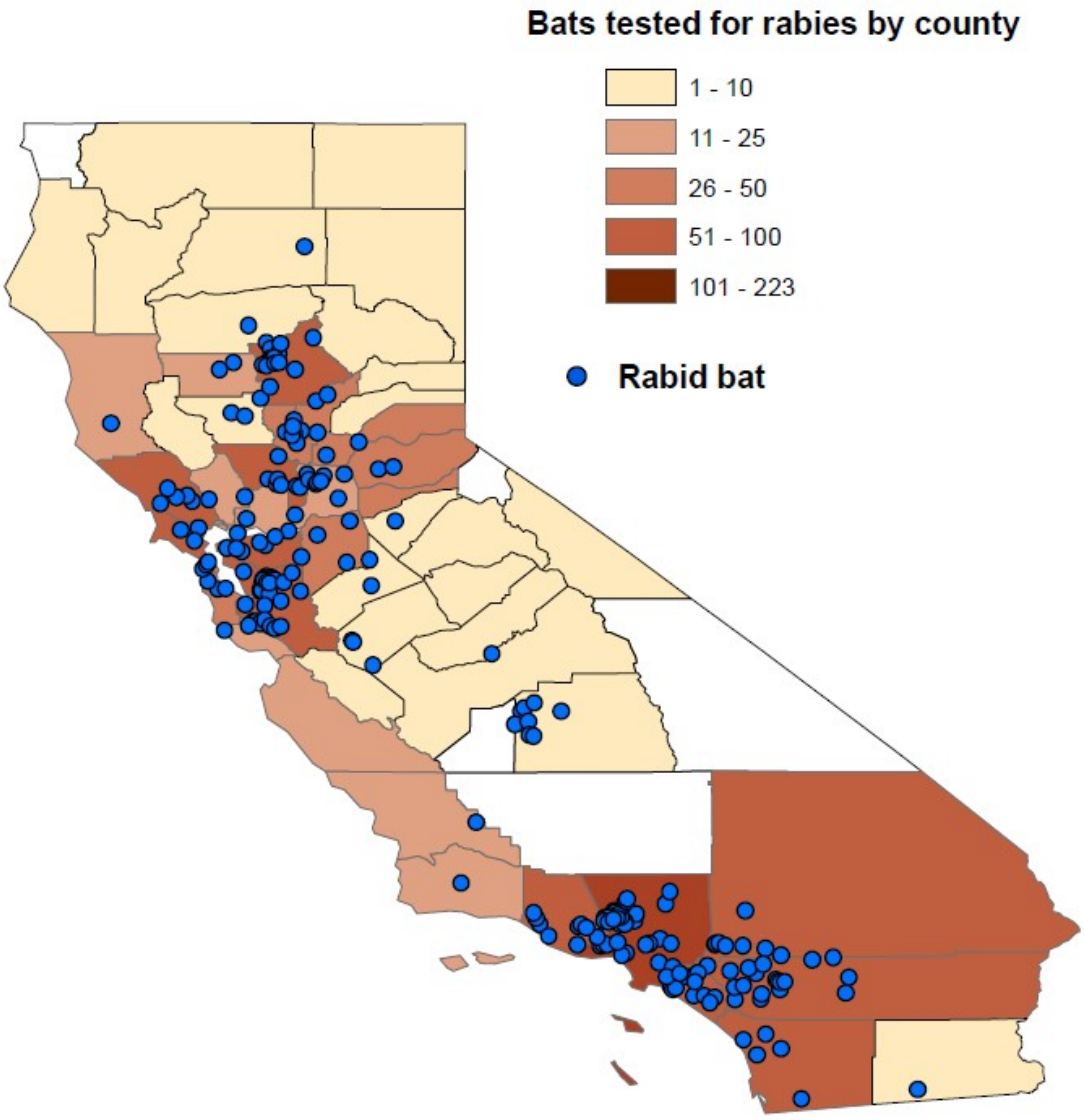

Figure B. Bats tested for rabies by county with positive cases by zip code of collection site (N=198), California, 2015.

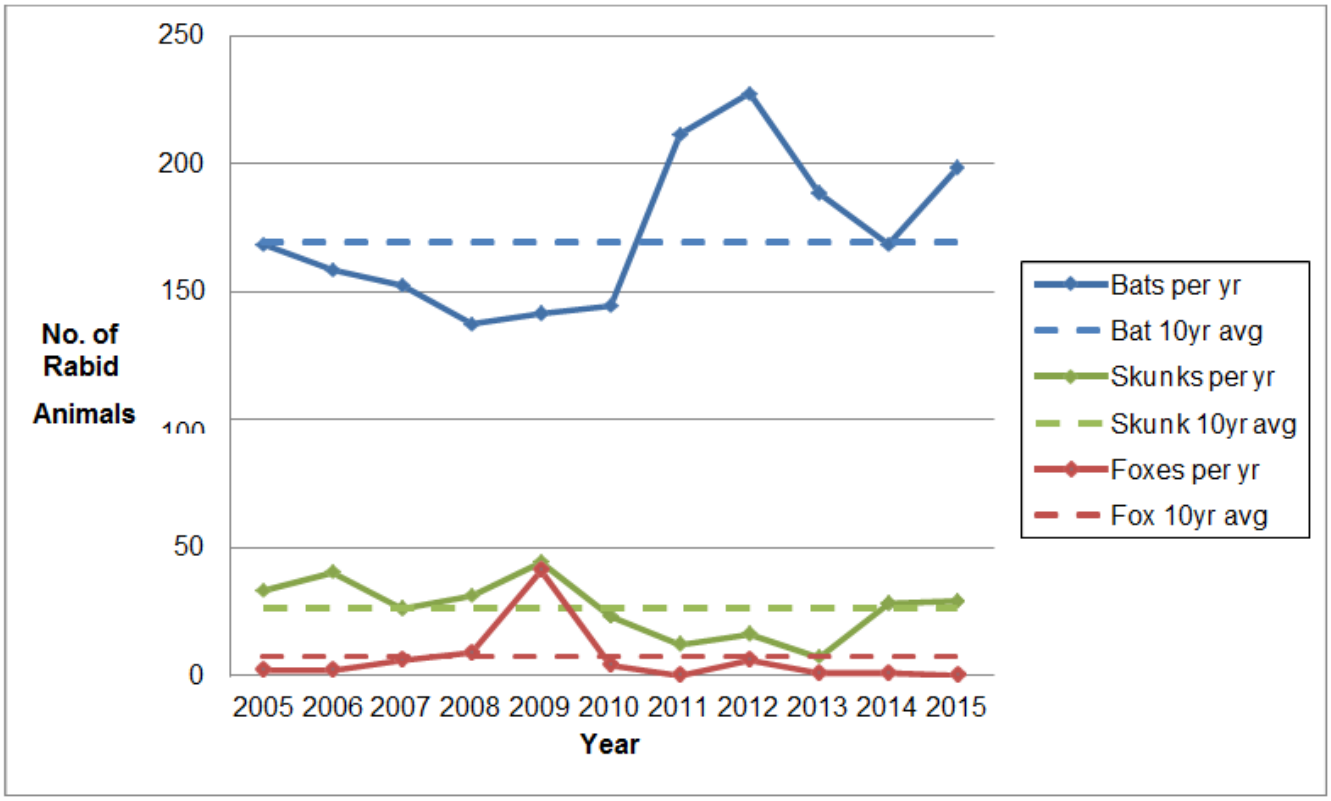

Figure C. Cases of rabies in wild animals in California, 2005-2015.

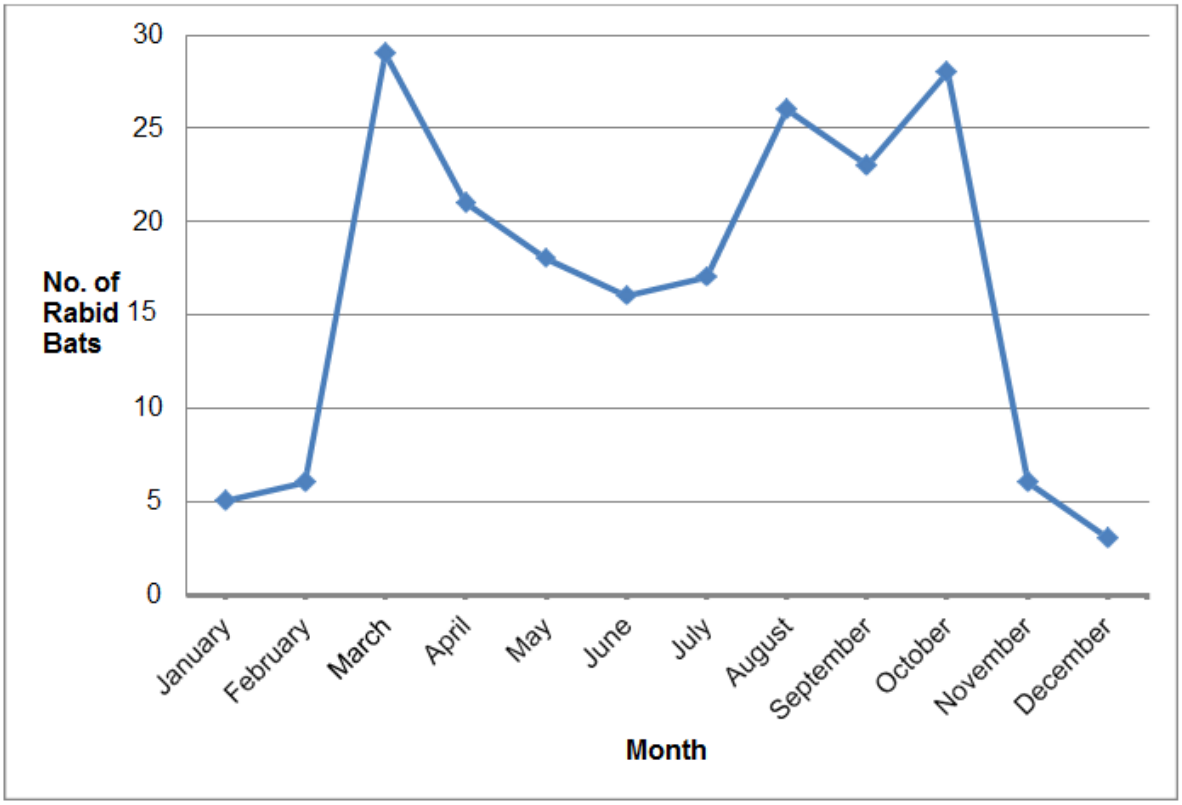

Figure D. Cases of rabies in bats by month of testing, California, 2015.

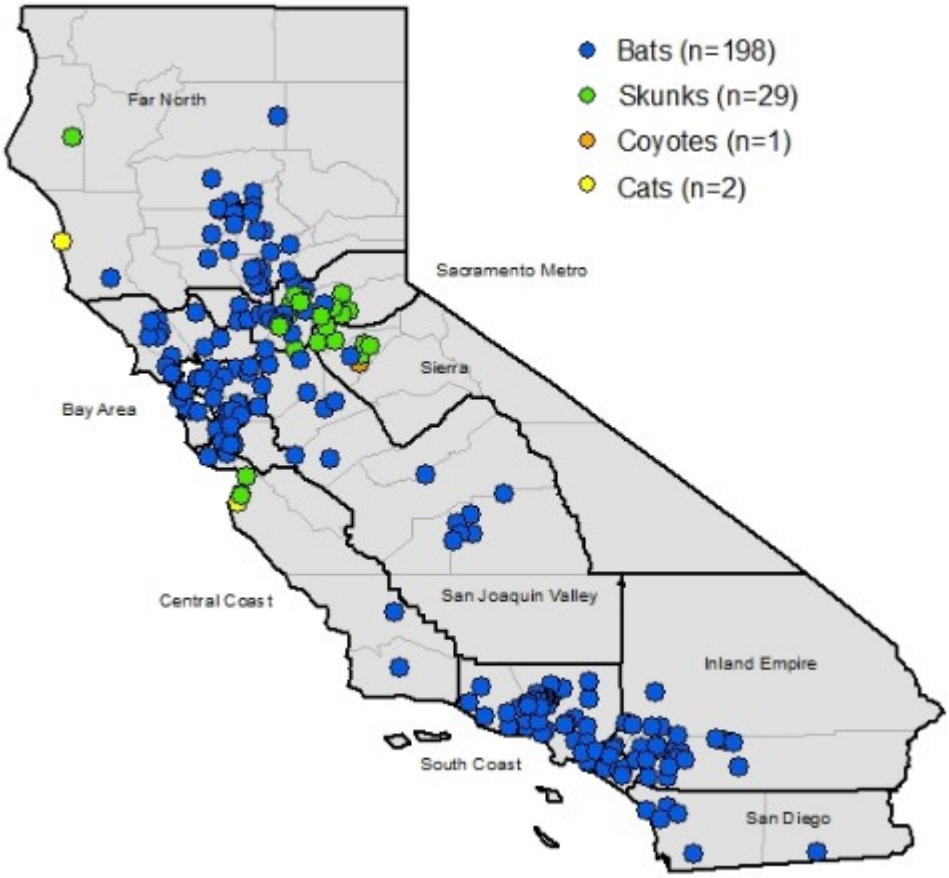

Figure E. Cases of rabies in domestic and wild animals by zip code of collection site, California, 2015

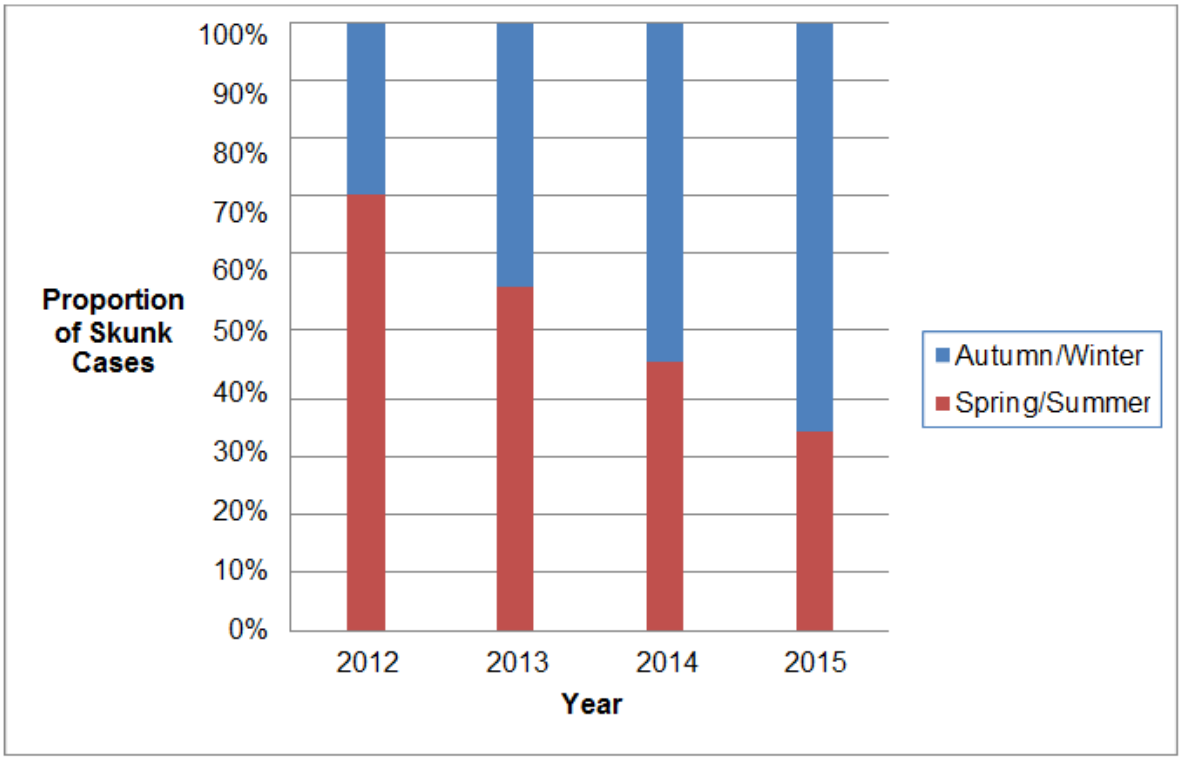

Figure F. Cases of rabies in skunks by seasons of testing, California, 2012-2015.

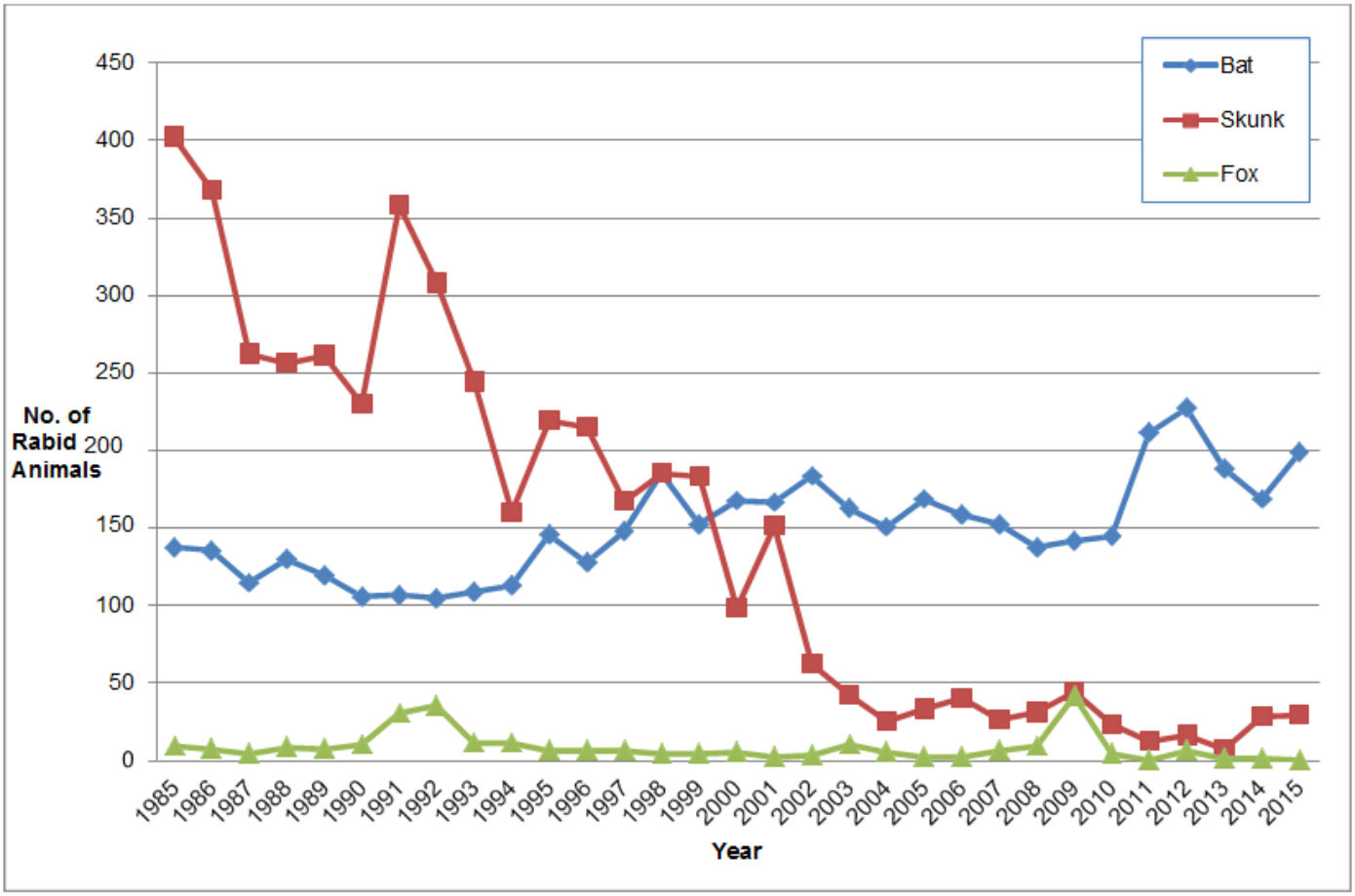

Figure G. Cases of rabies among wild animals in California, 1985-2015.