CDPH
California Department of Public Health

A Quick Overview of Vector-Borne Diseases

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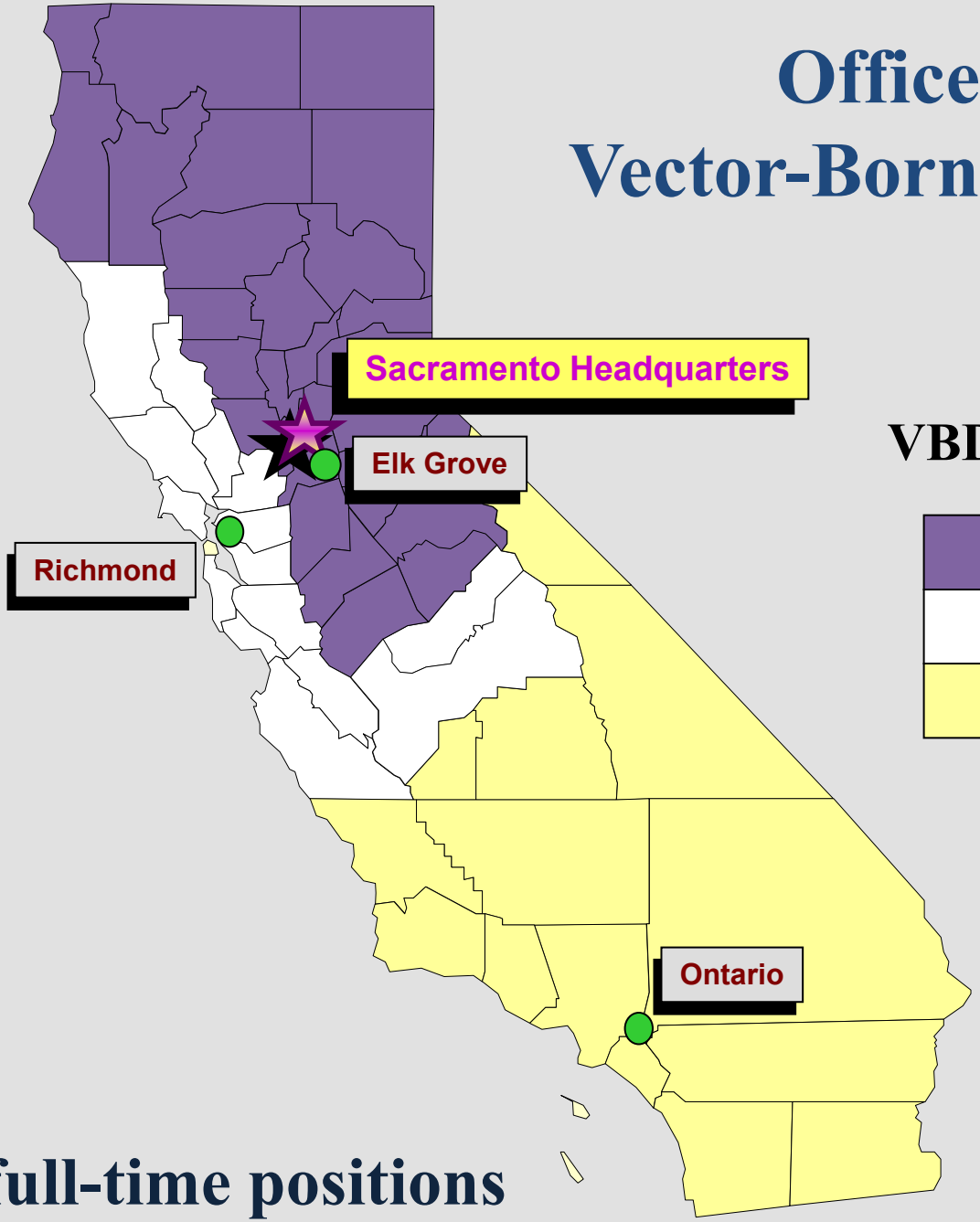
April 2019 VBDS Staff Meeting

Offices of CDPH
Vector-Borne Disease Section



VBDS Geographic Regions

	Northern Region
	Coastal Region
	Southern Region

30 full-time positions

VECTOR-BORNE DISEASE SECTION
CALIFORNIA DEPARTMENT OF PUBLIC HEALTH

VBDS Mission Statement

To protect the health and well-being of Californians, and visitors to California, from arthropod- and vertebrate-transmitted diseases and injurious pests.

Activities & Responsibilities

- Surveillance and Control
- Disease Investigation
- Laboratory Support
- Expertise and Education
- Pesticide Use Certification

Selected Vector-Borne Diseases

- **Flea-borne diseases:**
  - **Plague**
  - **Murine typhus**
  - **Bartonellosis (Cat scratch fever)**

- **Mosquito-borne diseases:**
  - **West Nile virus**
  - **St Louis encephalitis**
  - **Zika, dengue, chikungunya**
  - **Malaria**

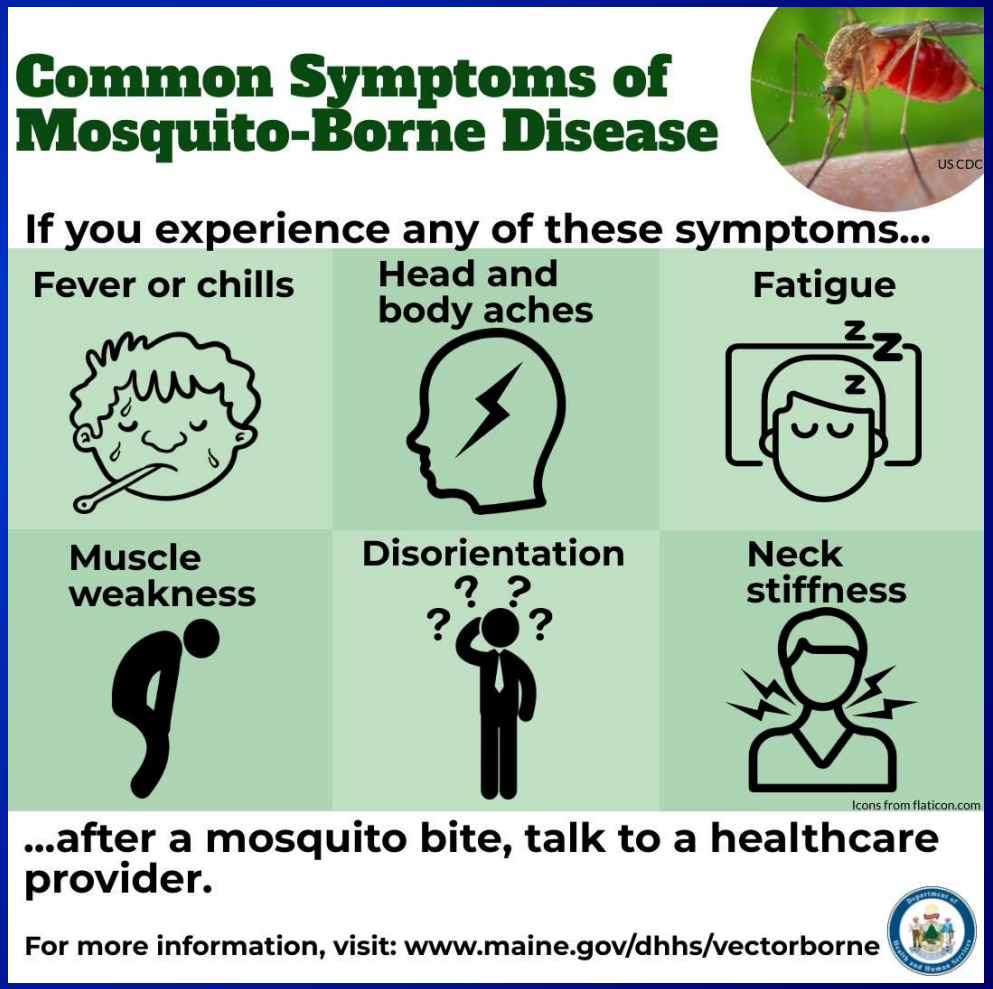
- **Rodent-borne disease:**
  - **Hantavirus**

- **Tick-borne diseases:**
  - **Lyme disease**
  - **Soft tick relapsing fever**
  - **Tularemia**
  - **Rocky Mountain spotted fever**
  - **Pacific Coast tic**
  - **Anaplasmosis**
  - **Ehrlichiosis**
  - **Babesiosis**

- **Triatomine-borne disease:**
  - **Chagas disease**

Things to Consider

- Be suspicious of “summer flu”
- Many VBDs share “flu-like” symptoms that are easily dismissed or misdiagnosed
- COVID-19 infections can divert attention from vector-borne diseases

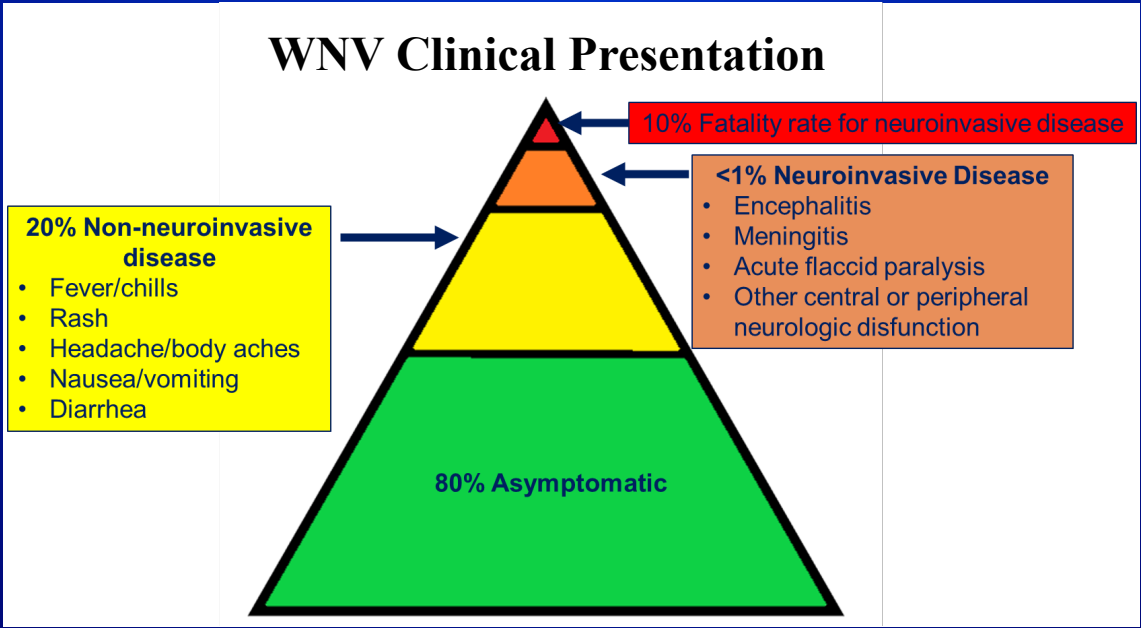


Things to Consider

- It's easy to miss vector-borne illnesses in differential diagnoses without adequate patient information
- Background on patient whereabouts, including recent activities, domestic, and international travel is crucial

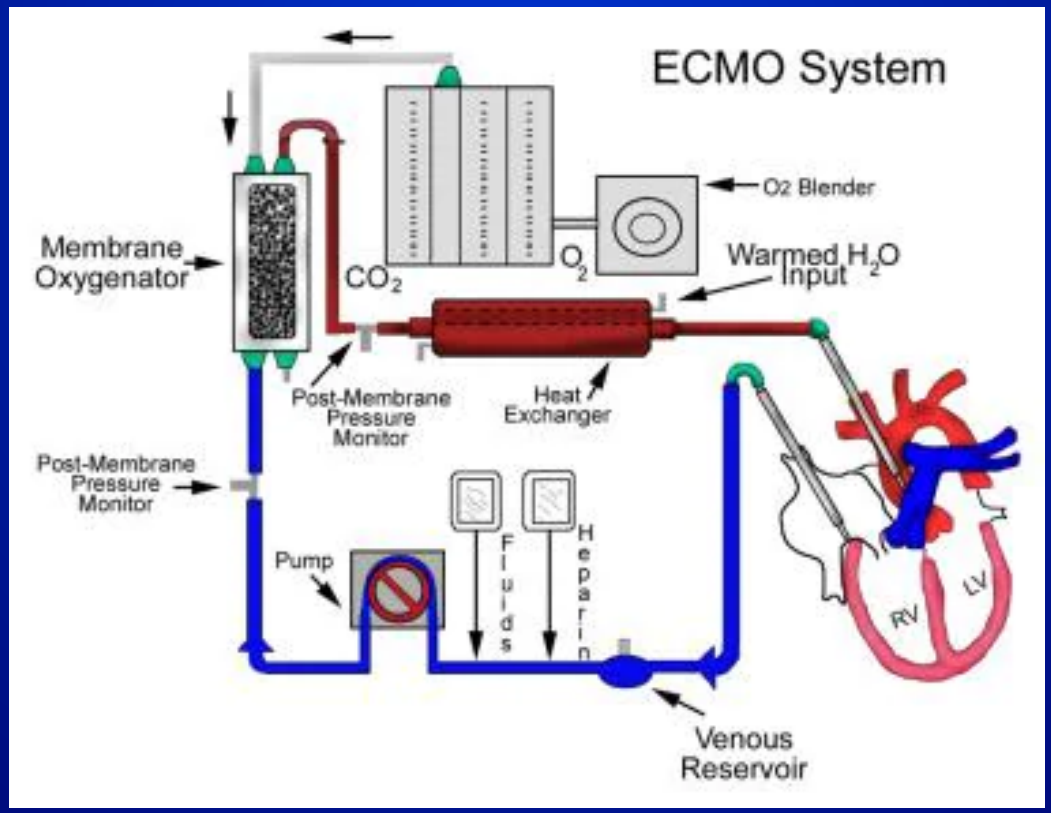
Things to Consider

- Vector-borne infections can present with a wide range of clinical symptoms
- A percentage of mosquito-borne viral infections including WNV, dengue, chikungunya, and Zika may produce subclinical symptoms or be asymptomatic



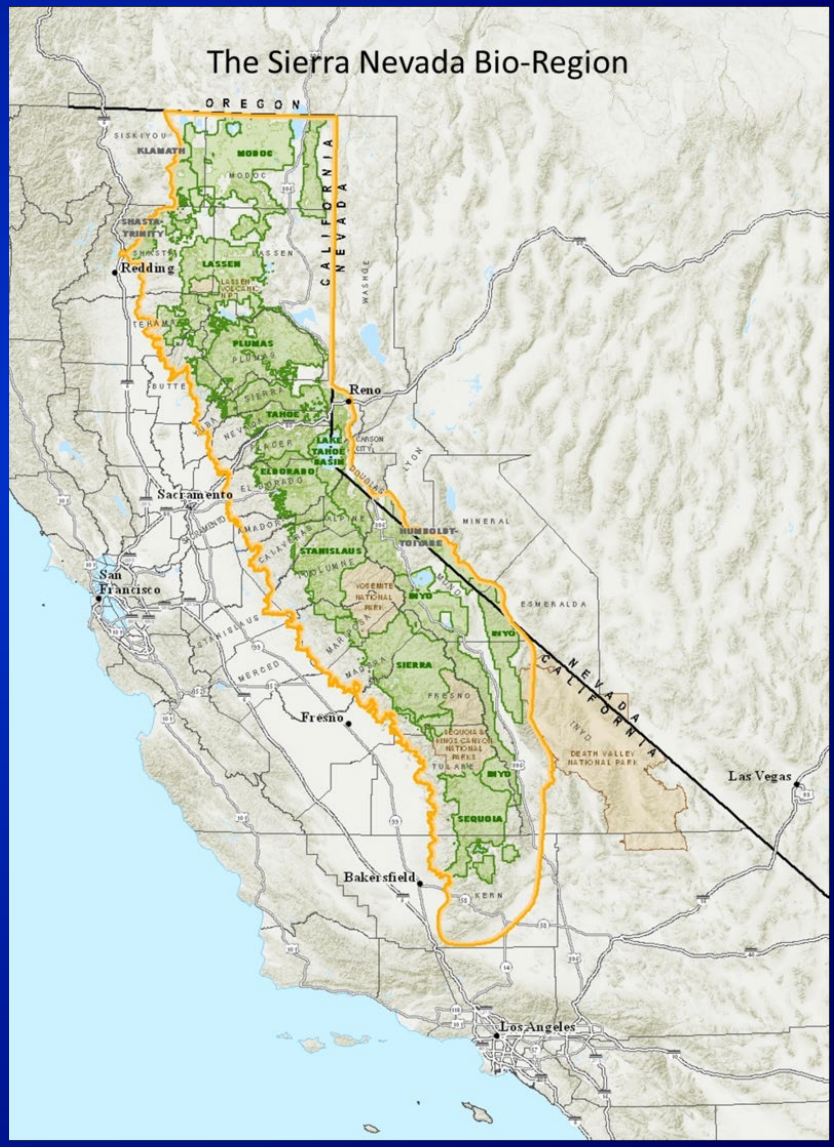
Things to Consider

- **Early diagnoses and treatment is critical to survival for some VBDs**
- **Especially hantavirus, RMSF, and plague**



Things to Consider

- Sierra Nevada Range is California's hot spot for plague, hantavirus, and STRF infections
- Mono County has the highest per-capita incidence of hantavirus infections in California



Things to Consider

- **Hantavirus and STRF infections are nearly always a result of rodents living inside structures alongside humans**

Things to Consider

- Outdoor and feral cats can increase the risk of plague by hunting rodents and harboring rodent fleas
- Free-roaming dogs can increase risk of RMSF by sustaining brown dog ticks around homes

Things to Consider

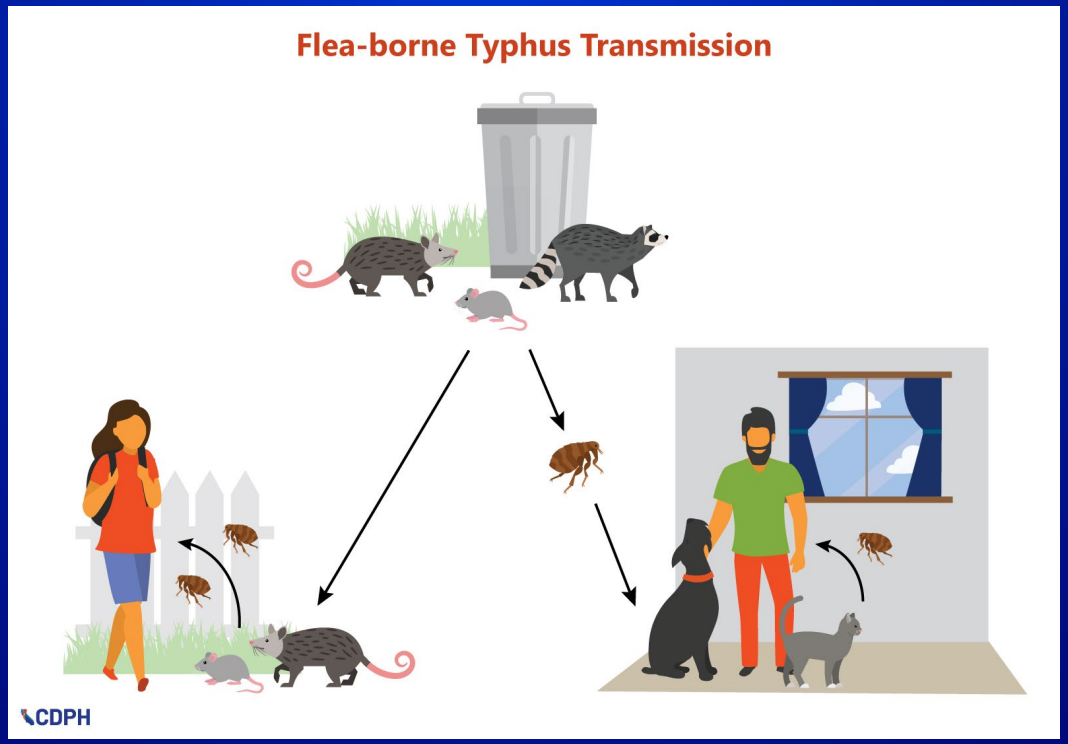
- **Hantavirus and RMSF infections have been prevalent on tribal lands in the desert southwest**

Things to Consider

- **Mosquito-borne infections are most common at lower elevations in urban and suburban environments**
- **Dengue, Zika, and chikungunya are transmitted only by highly urban *Aedes* mosquitoes**

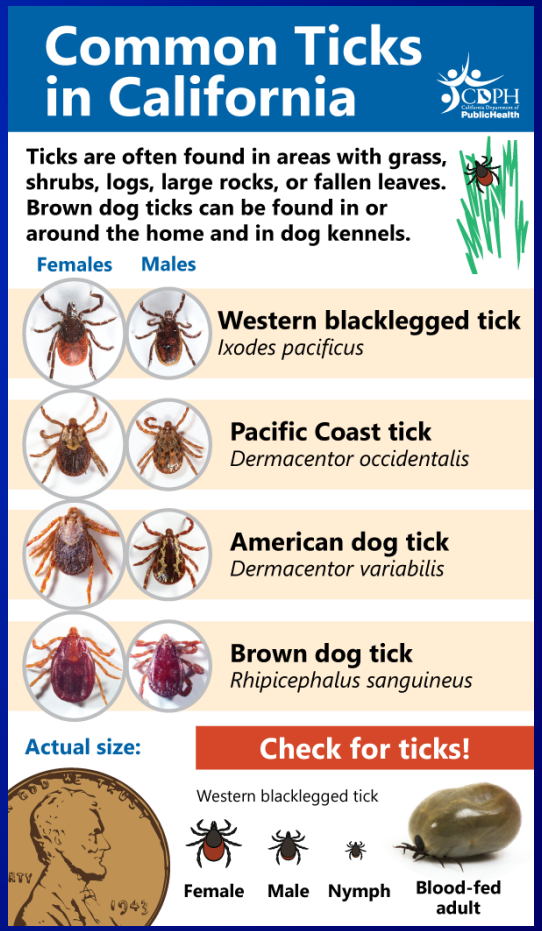
Things to Consider

- Presence of Norway rats, feral / outdoor cats, and urban wildlife (e.g. opossums, skunks, and racoons) can increase the risk of flea-borne typhus in Los Angeles and Orange counties



Things to Consider

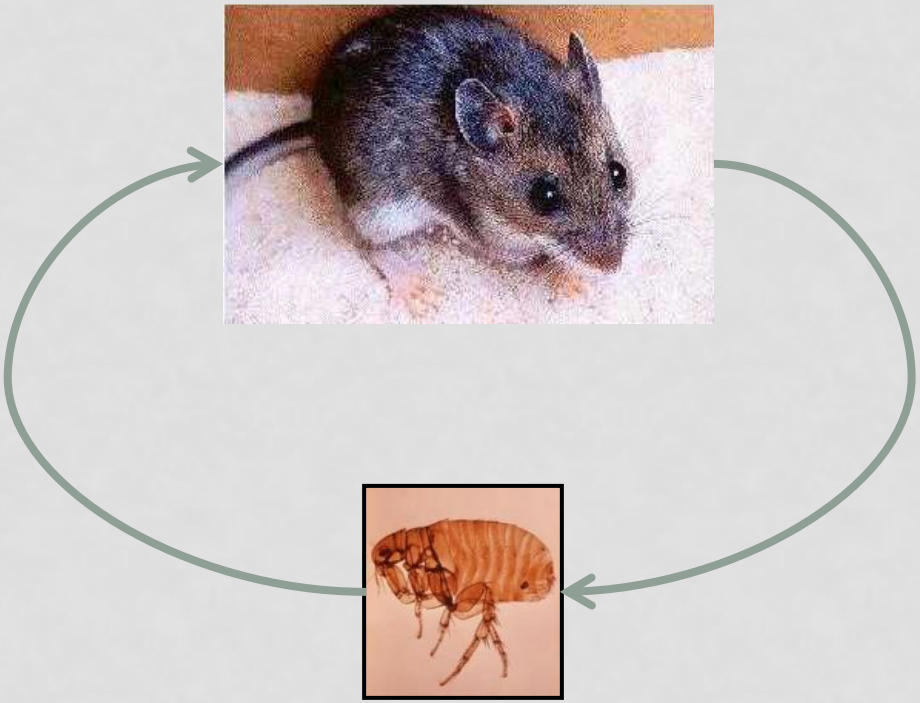
- **Extensive resources are at your fingertips on the CDC and CDPH websites**



PLAGUE (*YERSINIA PESTIS*)

- Bacteria
  - 50-60% fatality rate in humans if not treated
- Transmitted by the bite of an infected flea
- Typically found in enzootic cycle in the USA
- Epizootic cycles occur when there are increased periods of disease

Enzootic Cycle



RODENT RESERVOIRS

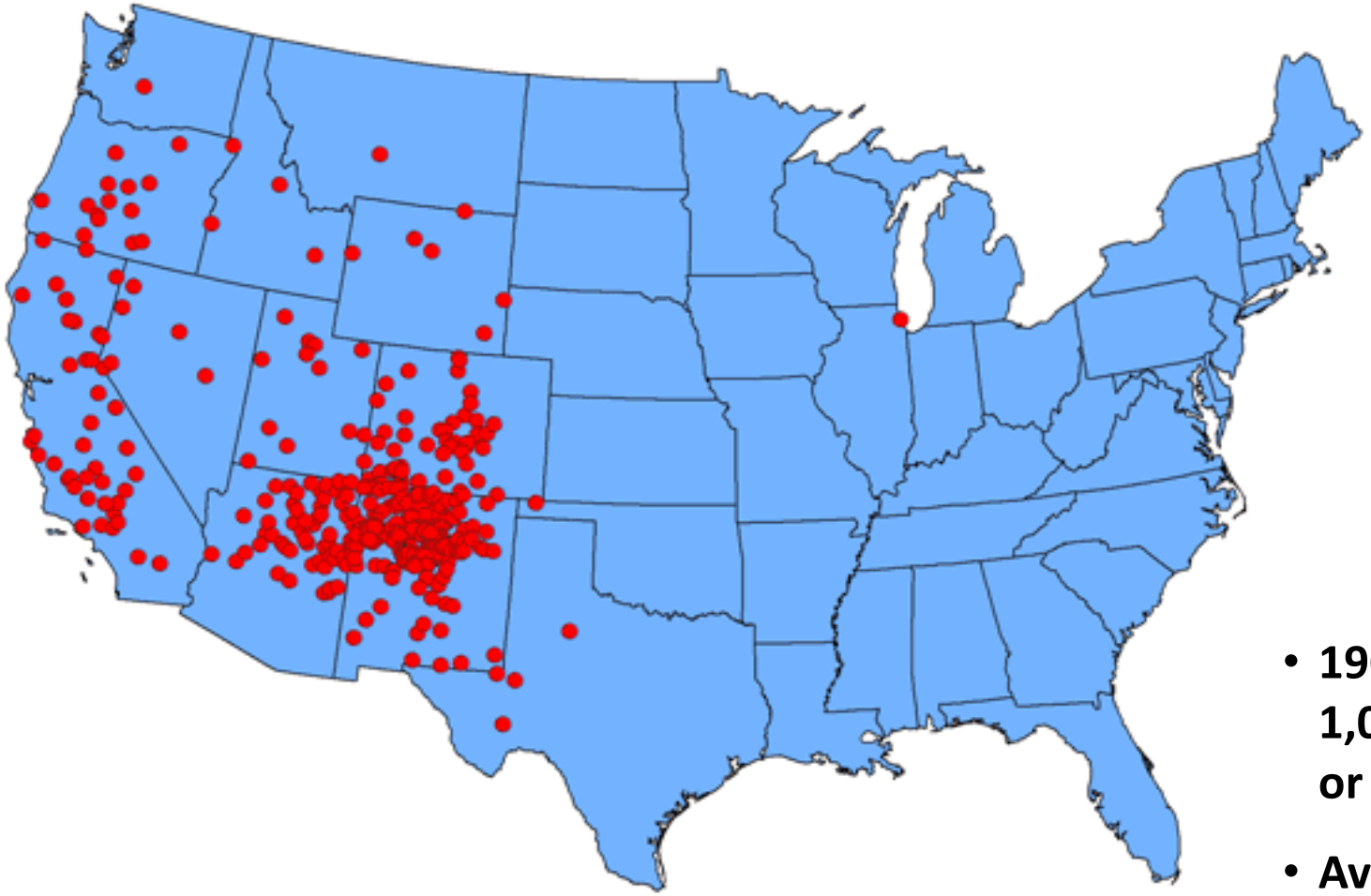
- **Resistant reservoirs:**
  deer mice, voles, chipmunks

Enzootic transmission

- **Susceptible/amplifying reservoirs:**
  ground squirrels, chipmunks

Epizootic transmission

Reported cases of human plague--United States, 1970-2012

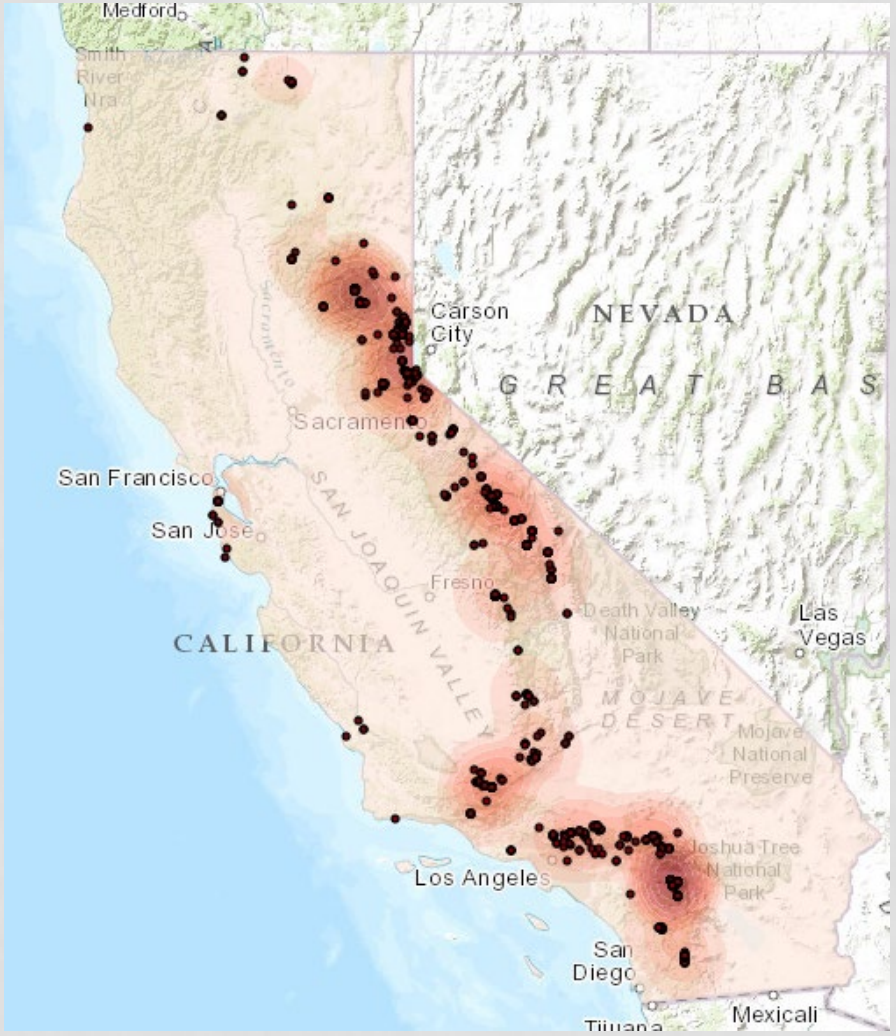


1 dot placed in county of exposure for each plague case

- **1900-2012: 1,006 confirmed or probable cases**
- **Avg 7 cases/year (Range 1-17)**
- **CA 1926-2006: 62 human cases**

CDC

PLAGUE IN CALIFORNIA RODENTS



Legend

1984 - 2013, Locations of Plague-positive Rodents

1984 - 2013, Density of Plague-positive Rodents

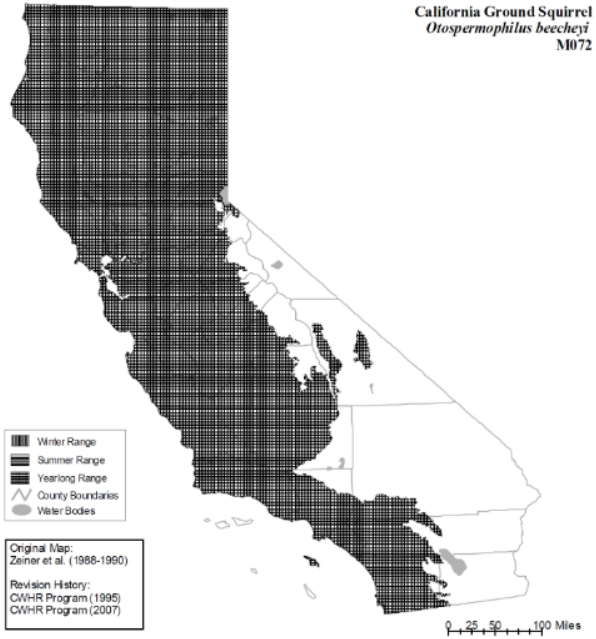
Class

High

Low

California Ground Squirrel (*Otospermophilus beecheyi*)

- **Species commonly associated with human plague cases**
- **Widely distributed & locally abundant**
- **Sylvatic & peridomestic**
- **Fleas abundant on animals & in burrows**
- **Fleas from these rodents are known plague vectors and will bite humans**



MODES OF TRANSMISSION

- Flea bite (most common)
- Direct contact with infected rodents or other animals (e.g. skinning animal)
- Inhalation of aerosols from close contact with felines or humans with plague pneumonia

HUMAN SYMPTOMS OF PLAGUE

- **Bubonic**
  - Swollen, tender lymph nodes (buboes) in neck, armpit or groin
  - Most common form in US (80% cases)

- **Septicemic**
  - Secondary blood infection

- **Pneumonic**
  - Primary or secondary lung infection (pneumonia)

FACTORS THAT INCREASE RISK OF HUMAN EXPOSURE

- History of plague transmission in the region
- High rodent populations (e.g., ground squirrels & chipmunks)
- High flea index
- High human-rodent contact (e.g., campgrounds)
- Evidence of rodent die off / fleas at burrow entrances
- Outdoor cats with hunting tendencies

Hantaviruses are found Worldwide

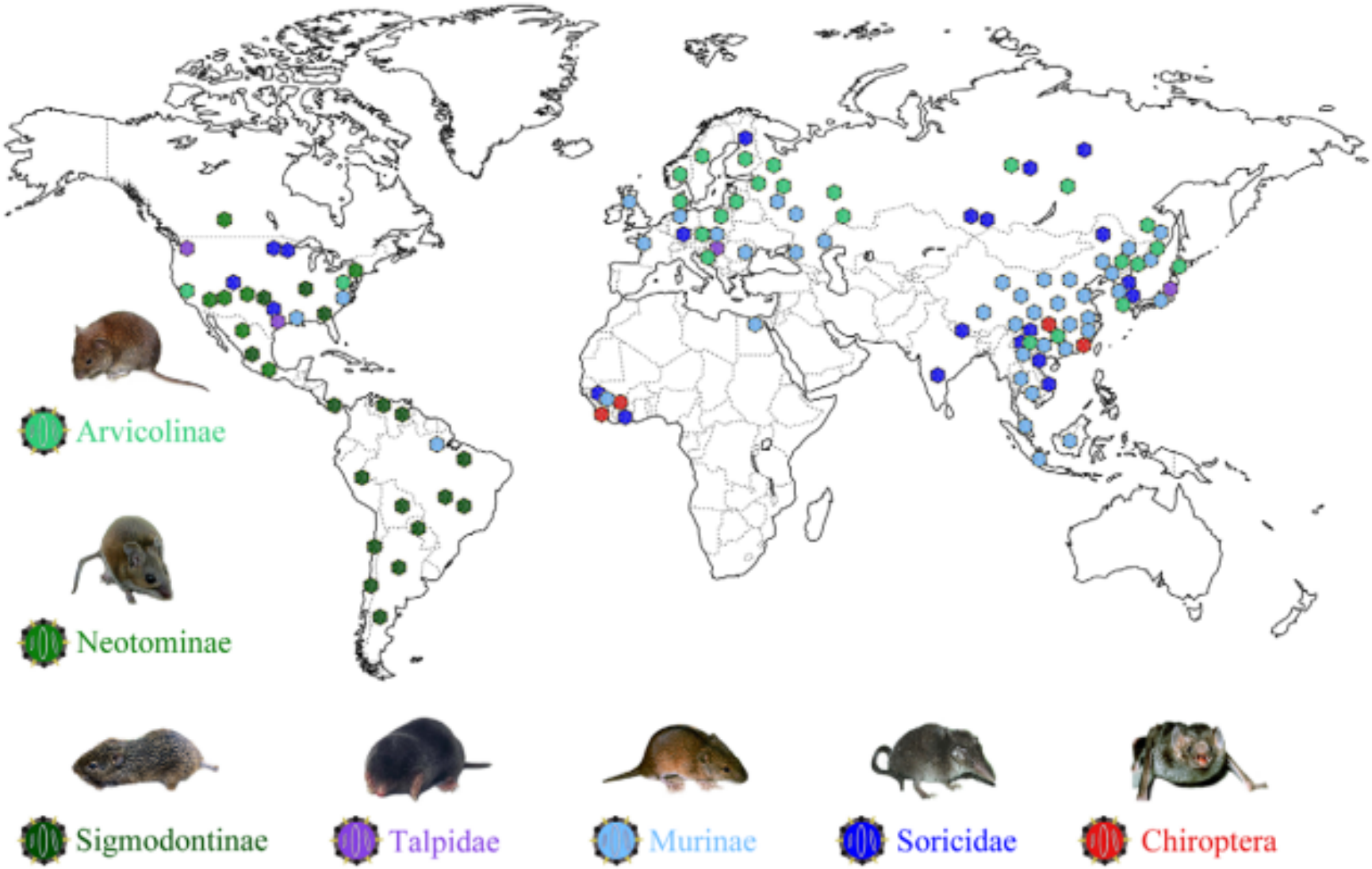


Figure 3. A map of the world illustrating the location of known hantaviruses by host group and associated mammalian hosts.
doi:10.1371/journal.ppat.1003159.g003

Hantavirus Pulmonary Syndrome in North America

- 1993 Four Corners outbreak
  - Unusual cluster of deaths
  - 23 cases of severe respiratory illness
  - Case fatality > 80%
- Etiology
  - "Sin Nombre" virus (SNV)
  - Deer mice (*Peromyscus maniculatus*) identified as reservoir and vector

Deer Mice and Hantavirus

- Abundant throughout California
- Readily enter homes and other buildings for food and shelter
- Statewide average ~12-14% seropositive
- Do not show signs of illness

Transmission of Hantaviruses

Chronically infected rodent

Horizontal transmission of infection by intraspecific aggressive behavior

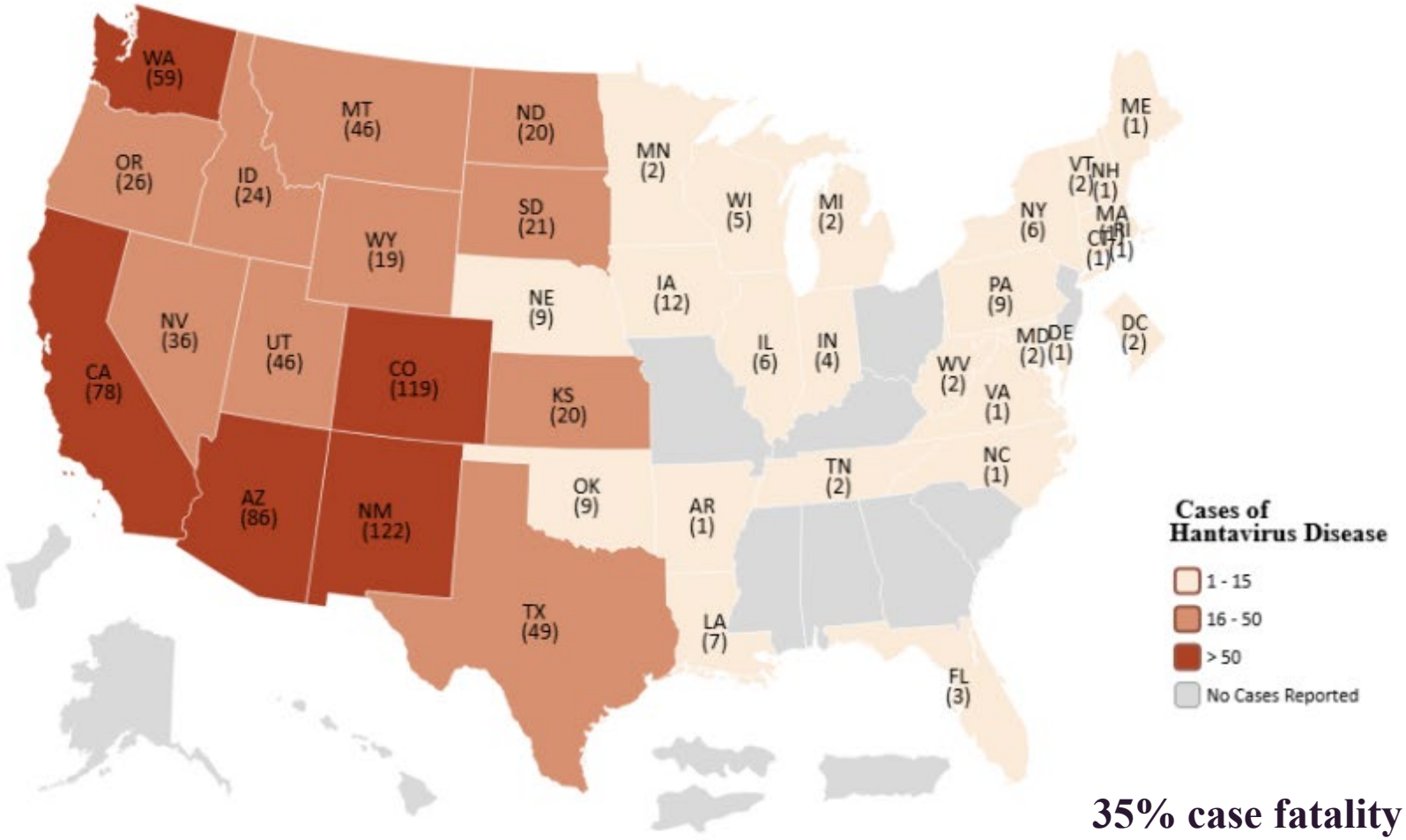
Virus is present in aerosolized excreta, particularly urine

Virus also present in throat swab and feces

Secondary aerosols, mucous membrane contact, and skin breaches are also sources of infection

CDC

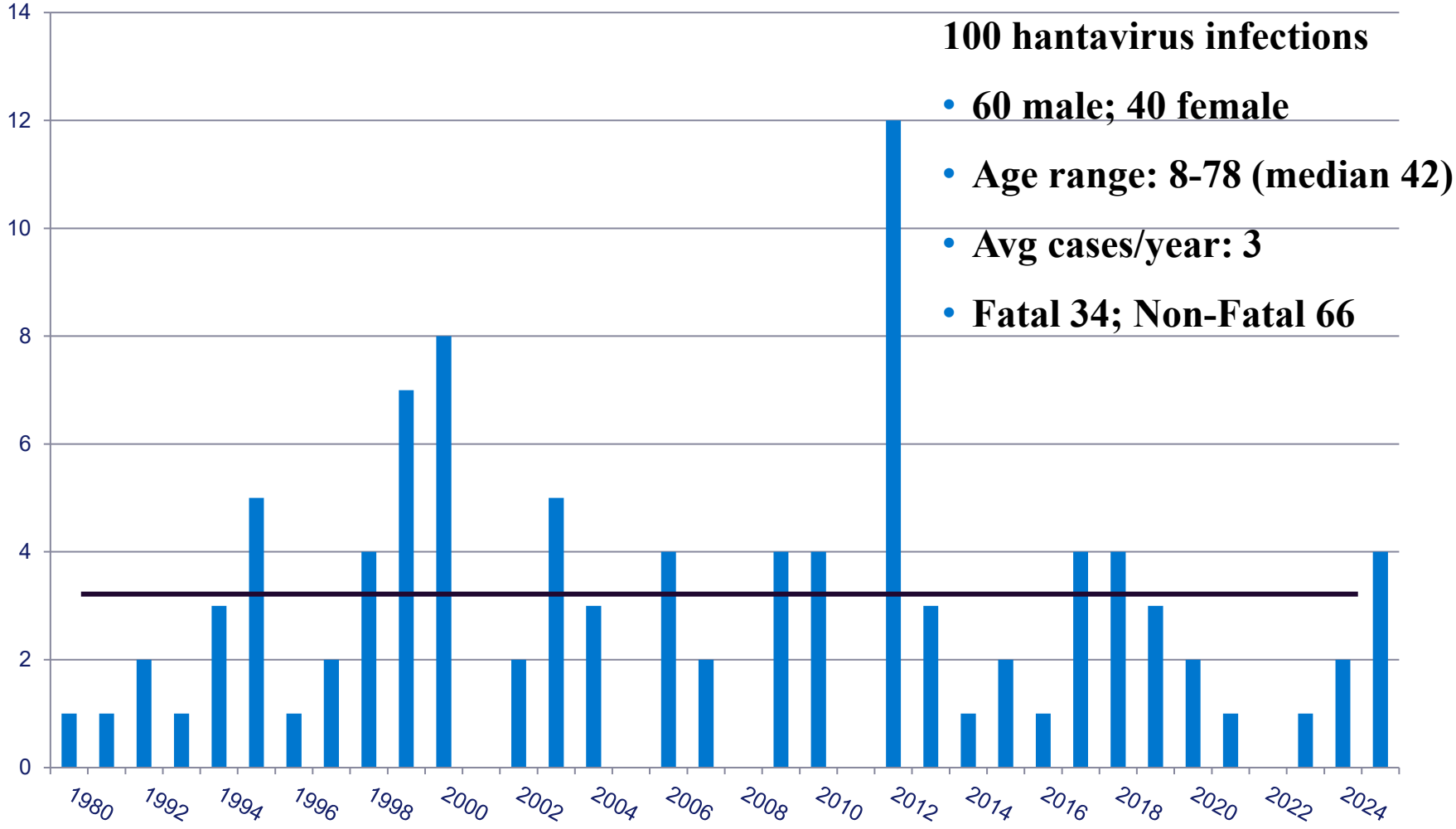
Map of U.S. Cumulative Cases of Hantavirus by State through 2022



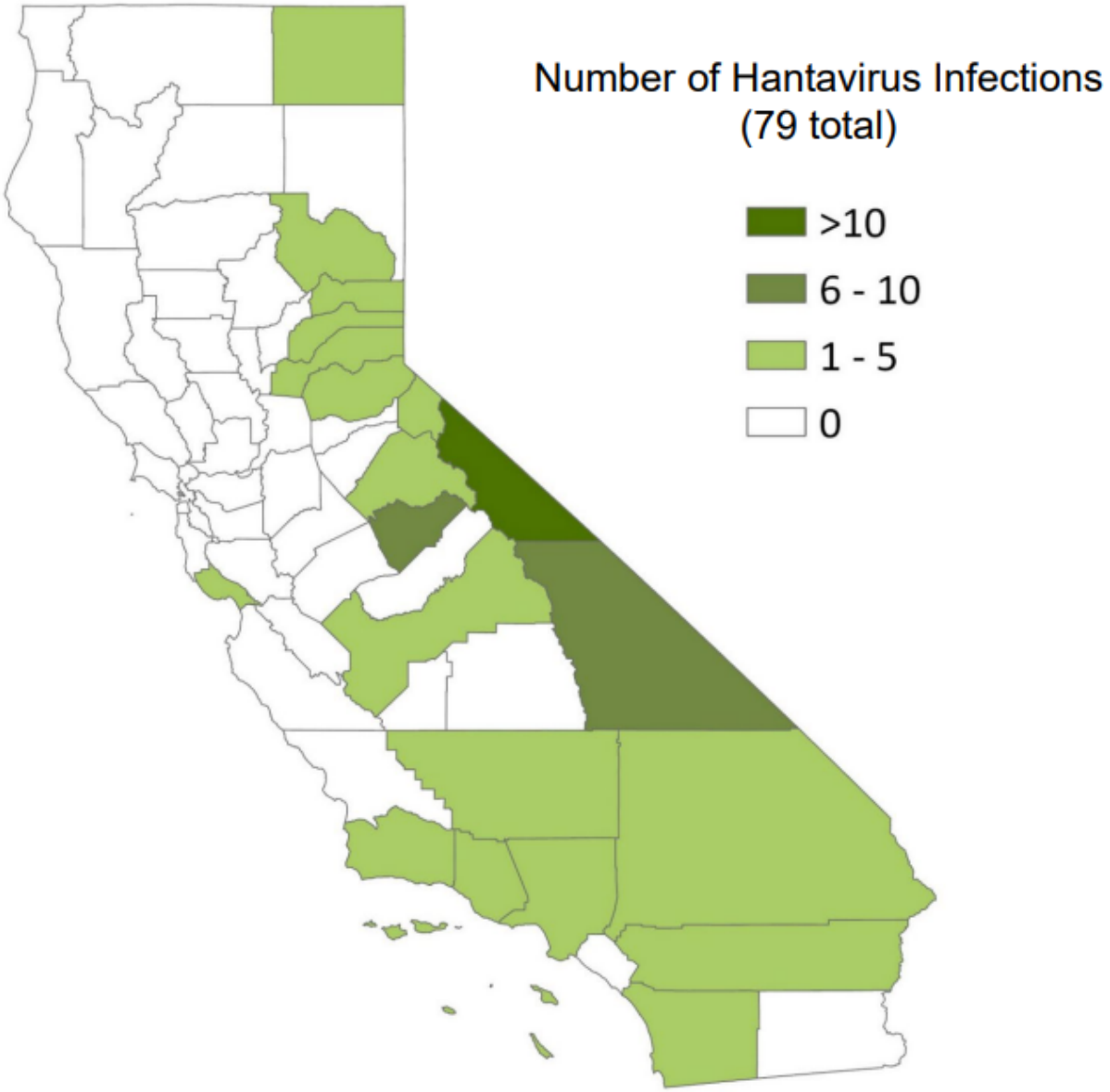
35% case fatality

All cases were confirmed between 1993-2022 and met the NNDSS case definition applicable at the time of reporting. Included in the sum total are 31 historical cases that occurred prior to 1993, but were confirmed retrospectively. Five cases had presumed exposure outside the United States.

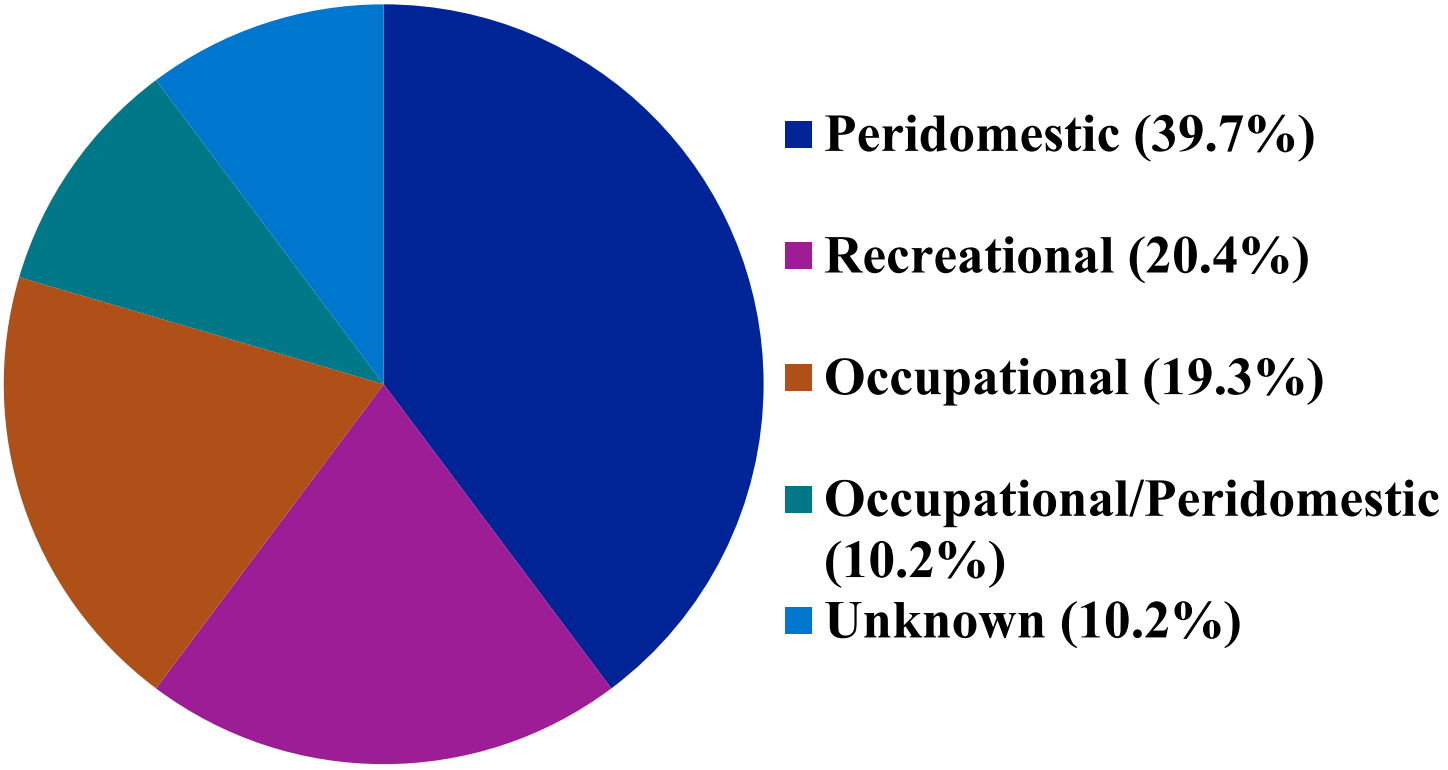
Hantavirus Infections in California Residents 1980-2025



County of Exposure for Reported Hantavirus Infections in California Residents, 1980 – 2024 *



Exposure Circumstances in CA Residents 1980 - 2025



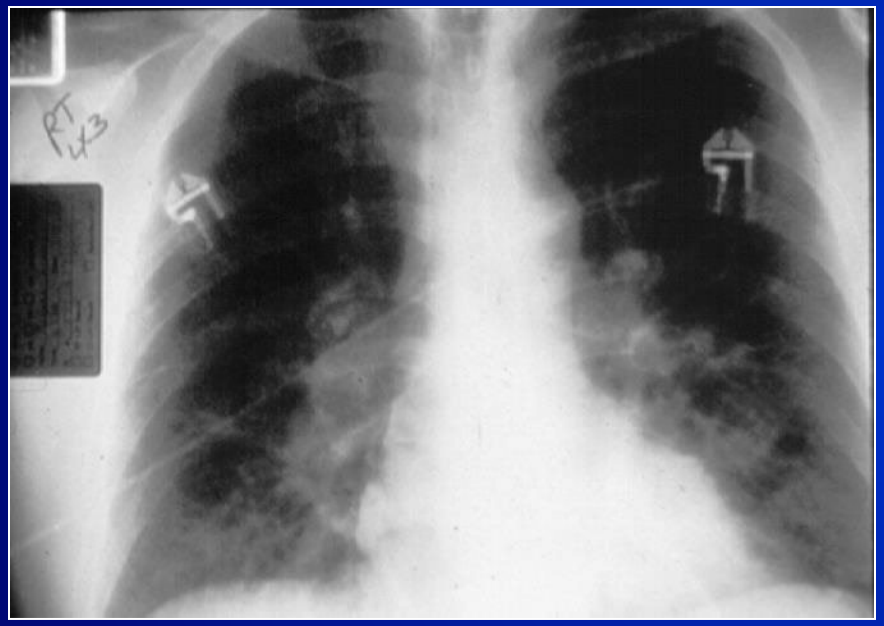
Risk of Contracting HPS

- Associated with increased numbers of deer mice in / around residence / structure
- Contact with rodent excrement puts one at greatest risk
  - Cleaning rodent-infested structures, especially those closed for a while (e.g., over winter)
  - Living / working in rodent-infested structures
- Most outdoor locations and activities considered low risk
- SNV transmission not documented person-to-person

Hantavirus Infection

- Incubation: 2-4 weeks (range 9-49 days)
- Prodrome Phase: 3 – 6 days
  - Clinical symptoms include headache, fever, muscle and body aches, chills, dry cough, nausea, vomiting, diarrhea
- Pulmonary Phase: Abrupt onset of respiratory distress, 4 – 24 hours
  - Pulmonary edema – fluid accumulation in the lungs
  - Hypoxia – tissues deprived of oxygen
  - Severe hypotension – low blood pressure

Acute Respiratory Distress Syndrome (ARDS)



3 days post-onset

6 hours later

Treatment of Hantavirus

- No effective antiviral agent currently available
- Treatment is largely supportive - need to be hospitalized quickly. Death occurs in roughly 30-40% of cases
- Extracorporeal Membrane Oxygenation (ECMO) as a last resort

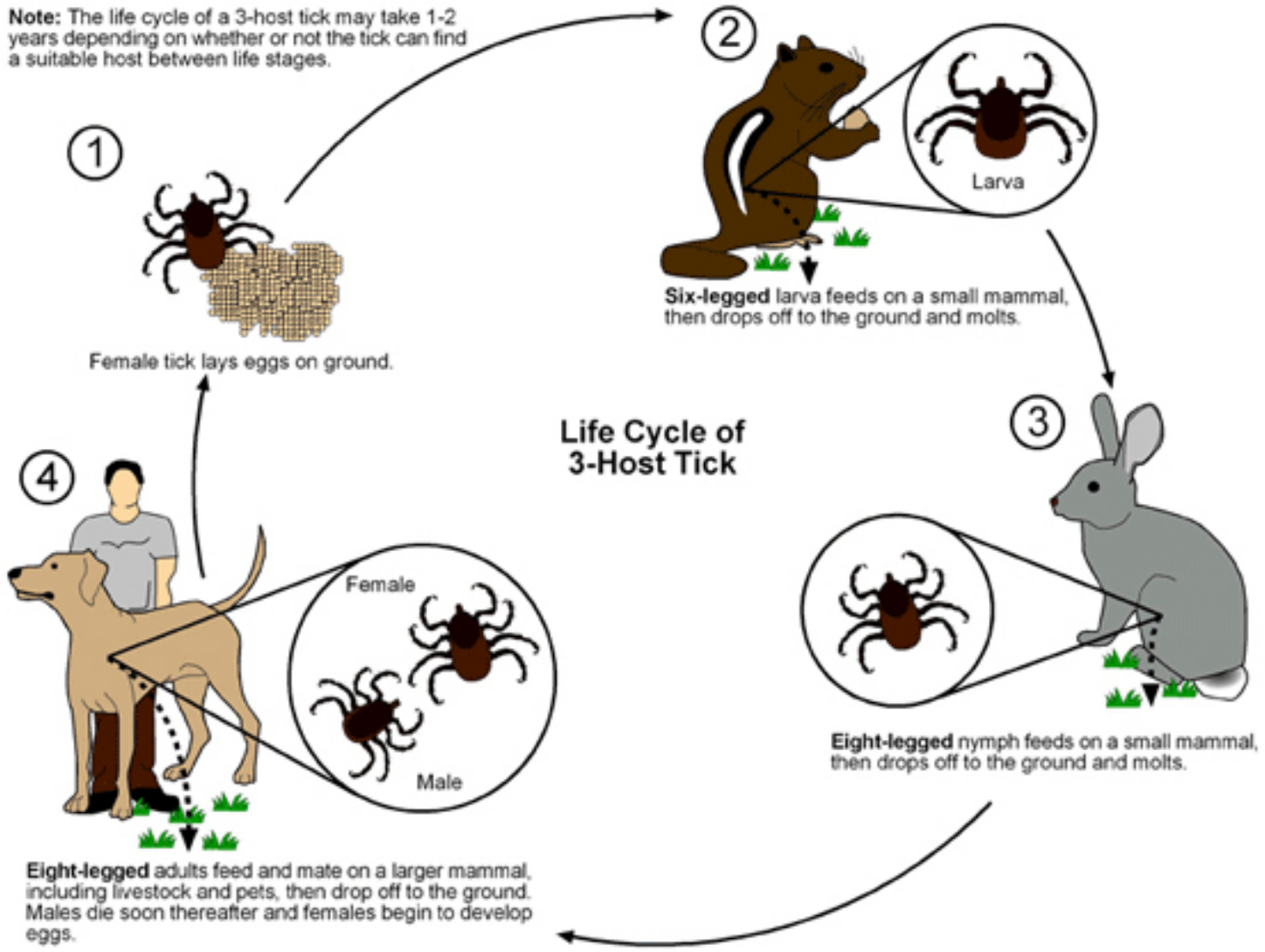
Risk Reduction / Personal Protection

- Education
  - Presentations, information brochures
- Exclude / reduce rodent harborage in structures
- Destruction of virus
  - Open structures to light and air prior to entering
  - Disinfect with bleach, Lysol, or household disinfectant
- Prevent inhalation of virus
  - Wear mask when cleaning (N-95 or better)
  - Mop rather than sweep / vacuum

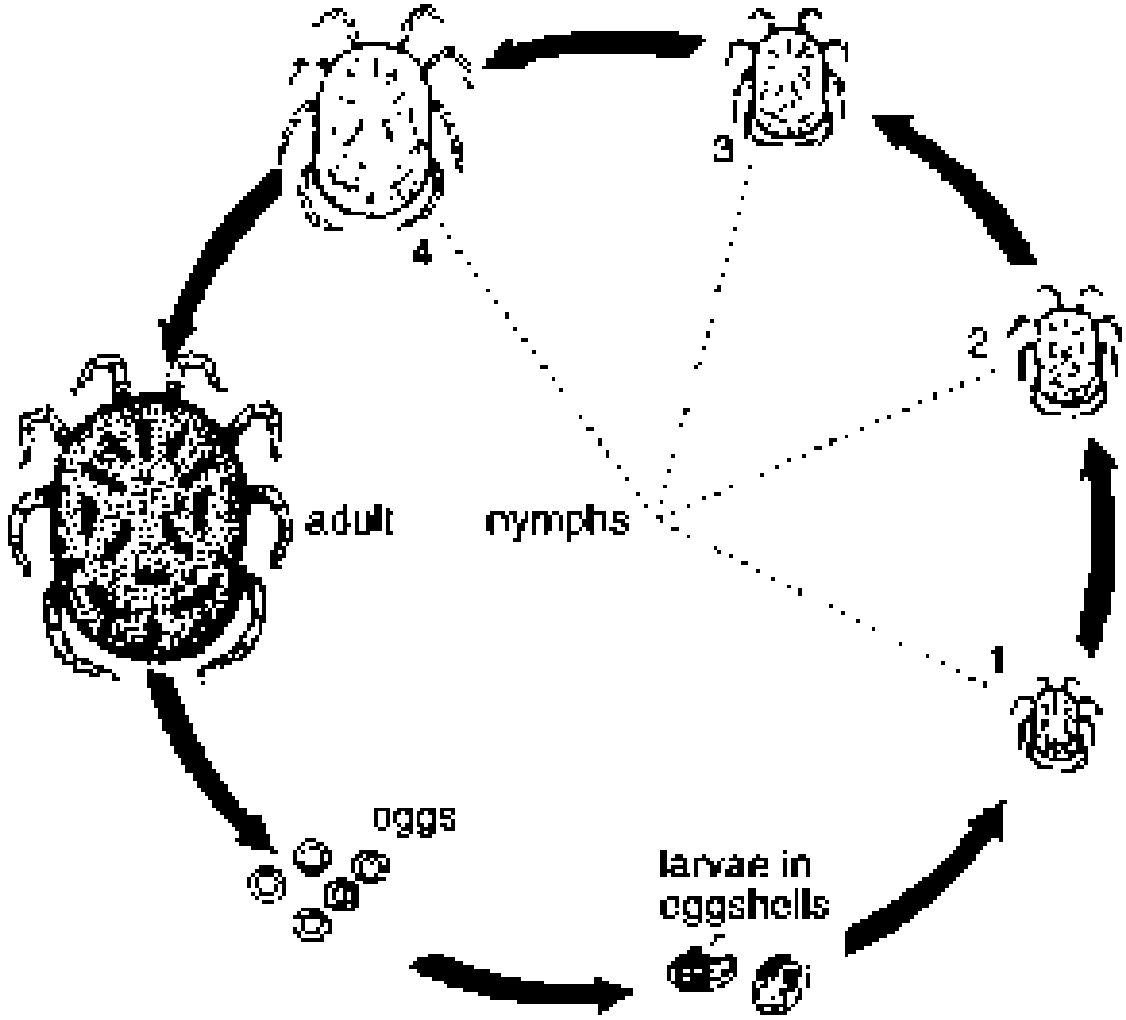
Tick-Borne Diseases

- Present in California
  - Lyme disease, RMSF, PCTF, STRF, Anaplasmosis
- Transmitted by bite of infected tick
  - Vector tick varies for each disease
  - "Hard" and "soft" ticks
- Distribution throughout California
  - Patchy distribution of vectors

Typical Hard Tick "Three Host" Life Cycle



Soft Tick Life Cycle



Personal Protection Measures Against Hard Ticks

- Avoid contact with ticks
- Wear protective clothing
- Apply tick repellent
  - DEET is most effective
- Apply permethrin products to clothes & shoes
- Daily tick check / removal

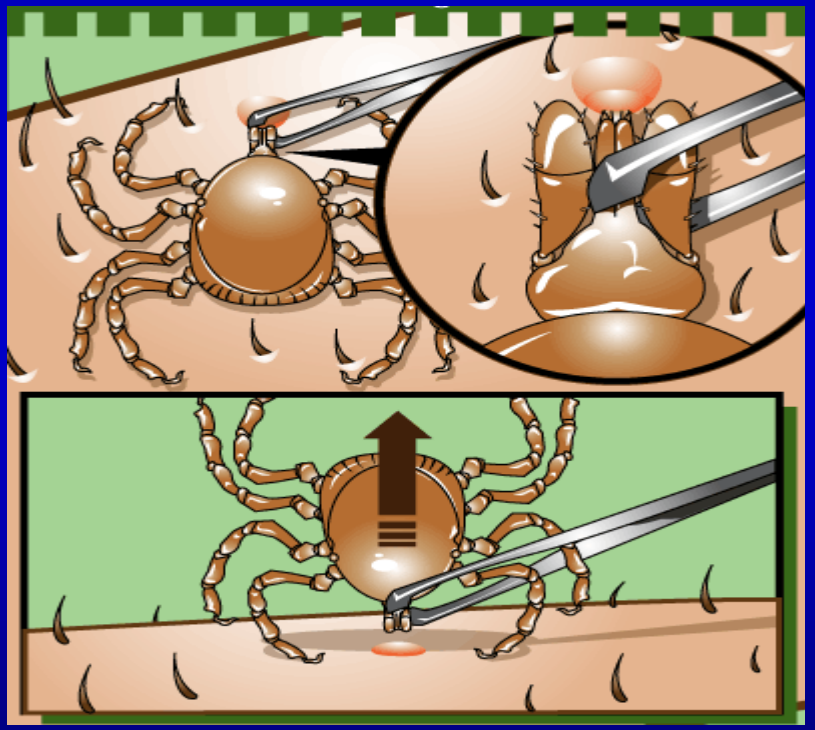
Proper Hard Tick Removal

1. Grasp tick with tweezers close to skin. Be careful not to squeeze the tick's abdomen

2. Pull the tick straight out, slowly and firmly. Do not jerk or twist the tick

3. Wash the area thoroughly

4. If possible, save the tick



Rocky Mountain Spotted Fever

- First described in the U.S. in 1890s
- About 2500 cases per year in the USA
- Intracellular bacteria (*Rickettsia rickettsii*) attacks endothelial cells and causes widespread vascular damage
- Sylvatic and urban tick vectors
- All stages of ticks can transmit the organism

Tick Vectors of RMSF

Rhipicephalus sanguineus
Brown dog tick

Dermacentor variabilis
American dog tick

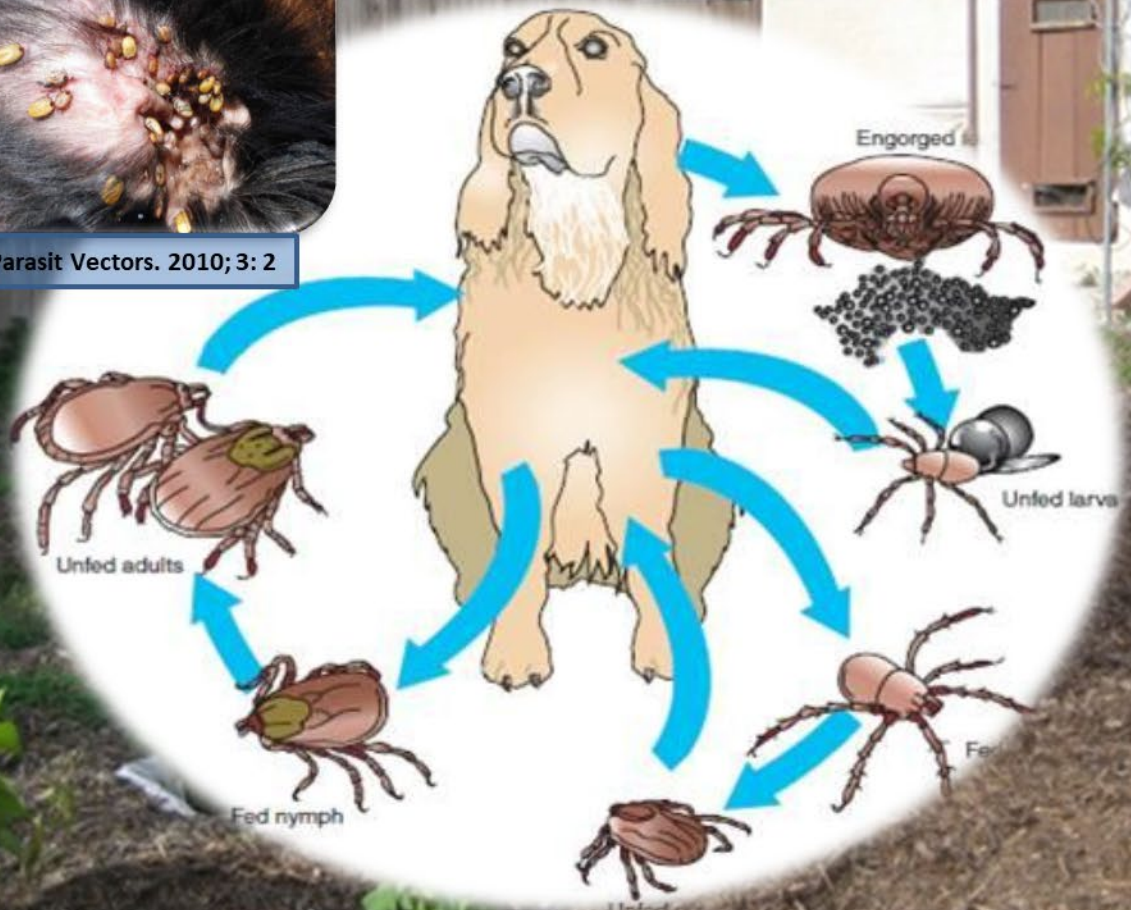
Dermacentor andersoni
Rocky Mountain wood tick

Tick Biology

- **Most ticks have moisture and temperature requirements**
  - **Vulnerable to desiccation, like high humidity, low tolerance for temperature extremes**
- **The brown dog tick is different**
  - **Thrives in hot climates**
  - **Requires less water than other ticks**
  - **Vulnerable to colder temperature**
  - **Can live indoors as long as there are dogs**
  - **Can crawl up and hide in walls, stucco, cracks, crevices, and carpet**

Brown Dog Tick (*Rhipicephalus sanguineus)* Life Cycle

Source: Parasit Vectors. 2010; 3: 2



Source: University of Florida

RMSF – Clinical Manifestation

- Early (first 4 days): fever, headache, myalgia, abdominal pain, light rash
  - Thrombocytopenia, hyponatremia, elevated liver enzymes may occur
- Late (day 5 or later): definitive petechial rash, altered mental status, seizures, cough, hypotension, arrhythmias, dyspnea, severe abdominal pain
- Many do not recall a tick bite

RMSF – The Rash

- Not consistent enough in presentation / timing for treatment decisions (only seen in 70-80%)
- Generally not apparent until day 2-5 of symptoms
- May begin on ankles, wrists, and forearms and spreads to trunk
- Petechial rash is a late finding, on or after day 6

Deaths Attributable to RMSF

- Historical case fatality rate 20-80% in untreated cases
- ARDS, DIC, and organ failure may begin around day 5 in severe cases
- Infection kills otherwise healthy adults and kids
- Median time from symptom onset to death is 8 days

Risk Factors for Death

- Lack of recognized tick bite
- Missed or late diagnosis
  - Presentation outside of summer tick season
  - Late onset of rash
  - Symptoms mimic more common illnesses
- Wrong antibiotic treatment:
  - e.g. broad-spectrum antibiotics are ineffective

RMSF – Intervention

- Treat EVERY SUSPECT CASE with doxycycline
- Community awareness / education is critical
- Canine-focused
  - Use long-acting acaracides (e.g. collars)
  - Limit free-roaming
  - Spay/neuter
- Environment
  - Remove outdoor clutter that can harbor / shelter ticks
  - Apply acaracides to knock down large tick infestations
  - Seals cracks and crevices on homes

American Trypanosomiasis (Chagas Disease)

- **Protozoan parasite *Trypanosoma cruzi***
- **Infects >100 species of mammals**
- **Vectored by >100 species of Triatomid bugs via parasite-contaminated feces entering skin lesions, eyes, or mouth**
- **Other modes include contaminated food, blood transfusion, congenital, and organ transplant**
- **Estimated 5.7 million people infected in Latin America, with 30,000 new cases annually**

WHO 2015

Trypanosoma cruzi

DPDx

Triatomine Bug Stages

Mammalian Stages

1. Triatomine bug takes a blood meal
(passes metacyclic trypomastigotes in feces, trypomastigotes enter bite wound or mucosal membranes, such as the conjunctiva)

2. Metacyclic trypomastigotes penetrate various cells at bite wound site. Inside cells they transform into amastigotes.

3. Amastigotes multiply by binary fission in cells of infected tissues.

4. Intracellular amastigotes transform into trypomastigotes, then burst out of the cell and enter the bloodstream.

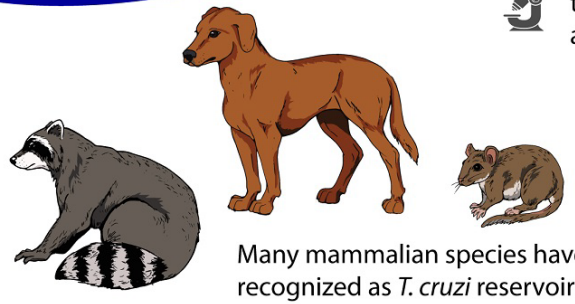
Trypomastigotes can infect other cells and transform into intracellular amastigotes in new infection sites.

5. Triatomine bug takes a blood meal
(trypomastigotes ingested)

6. Epimastigotes in midgut

7. Multiply in midgut

8. Metacyclic trypomastigotes in hindgut



Many mammalian species have been recognized as *T. cruzi* reservoir hosts.

CDC

Infective stage

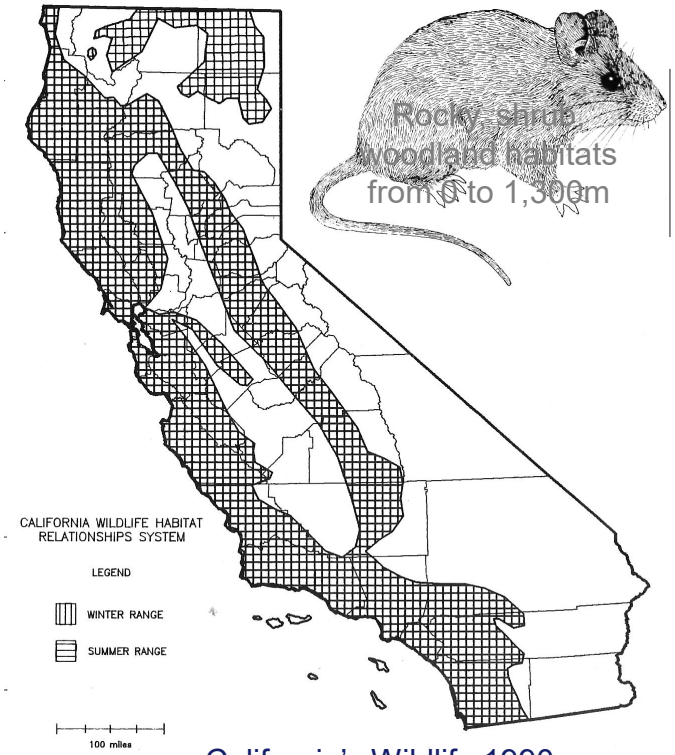
Diagnostic stage

T. cruzi transmission in California

Main reservoir host

Dusky-footed woodrat
Neotoma fuscipes

Infected via eating infected bugs



California's Wildlife 1990

Main vector

Western conenose bug
Triatoma protracta

Distribution mirrors woodrat hosts

Western Cone-Nosed Bug

Triatoma protracta

- **Locally abundant in undeveloped areas**
- **Long lived with life cycle taking over one year**
- **Adult flights occur primarily during the summer season, on warm evenings (65-84°F; 1st hour after dark). Attracted to lights**
- **May occasionally produce offspring inside homes, but does not colonize**
- ***T. cruzi* infected bugs found throughout CA – percentages vary**

Chagas Disease in Humans

Acute Phase

- High blood parasitemia for ~ 2 months
- Often asymptomatic or mild
- Symptomatic cases vary

Chronic Phase

- Parasites hide in target tissues, especially muscles of cardiac and digestive systems
- Lifelong infection with different clinical forms (asymptomatic, cardiac, digestive, mixed)
- Can be fatal

Local Transmission is Possible, but Very Rare

Tuolumne County, 1982
Patient hospitalized
Confirmed local exposure

Ventura County, 2009
Asymptomatic blood donor
Probable local exposure

Los Angeles County, 2017
Patient hospitalized
Probable local exposure

Public Health Significance of *Triatoma protracta*

- ***Triatoma*** **bite hypersensitivity is the primary public health concern in California and the USA**
- **Estimated 5-15% bite victims experience severe bite reactions**
- **Sensitized individuals can try to minimize exposure by making home less attractive (i.e., lights) and "bug proof". Severe cases should consider relocation away from rural or suburban peripheries**

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