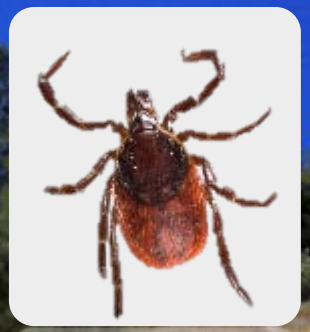
# Epidemiology and Prevention of Tick-Borne Diseases in California

Information for Physicians
and
Other Health-Care
and
Public Health Professionals



# Objectives of this Presentation

- Familiarize health-care providers with California ticks and the diseases they carry
- Describe the epidemiology of selected tick-borne diseases in California
- Describe tick exposure risk in California, including pertinent ecology
- Provide tick-bite prevention and tick removal information
- Provide information on educational resources available at the California Department of Public Health

Note: Photos, tables, and diagrams originate with the California Department of Public Health or are publically available clipart except where otherwise indicated.

# Table of Contents

**Advance slides by tapping [enter] or the down arrow**
**Clicking on the title slides below will take you to that subject section**
**The button at the end of each section will take you back to this slide**


- Introduction to tick-borne diseases in California
- Tick species and biology in California
- Epidemiology in California of:
  - More common
    - Lyme disease
    - Spotted fever group *Rickettsia* - including Rocky Mountain spotted fever (*Rickettsia rickettsii*)
    - Tick-borne relapsing fever
  - Less common
    - Anaplasmosis
    - Babesiosis
    - Tularemia
    - Colorado tick fever
    - Tick paralysis
- Prevention of tick bites
- Resources available from the California Department of Public Health
- Self-test quiz

# Tick-Borne Diseases in California

| Disease | Agent | Tick vector |
|---|---|---|
| Lyme disease | *Borrelia burgdorferi* | *Ixodes pacificus* |
| Rocky Mountain spotted fever | *Rickettsia rickettsii* | *Dermacentor* spp./ *Rhipicephalus sanguineus* |
| Tick-borne relapsing fever | *Borrelia hermsii* | *Ornithodoros hermsii* |
| Spotted fever group *Rickettsia* | *Rickettsia* 364D (*Rickettsia philipii*) | *Dermacentor occidentalis* |
| Anaplasmosis | *Anaplasma phagocytophilum* | *Ixodes pacificus* |
| Babesiosis | *Babesia duncani* | Unknown |
| Colorado tick fever (CTF) | CTF virus | *Dermacentor andersoni* |
| Tularemia | *Francisella tularensis* | multiple species |
| Tick paralysis | Toxin | multiple species |

# Most tick-borne diseases are reportable

(California Code of Regulations, Title 17)

Click here to see list of reportable conditions:

http://www.cdph.ca.gov/healthinfo/Pages/ReportableDiseases.aspx

# Number of Human Tick-borne Disease Cases* Reported in CA, 2004-2013

| Disease | Number of Reported Confirmed Cases |
|---|---|
| Lyme disease | 765 |
| Tick-borne relapsing fever | 61 |
| Tularemia** | 13 |
| Rocky Mountain spotted fever | 10 |
| Spotted fever group (364D, described 2008) | 12 |
| Anaplasmosis | 6 |
| Babesiosis | 2 |

* Number reflects only those cases that fit the surveillance criteria for a confirmed case
** Number reflects only cases for which tick-bite likely exposure

Click to go table of contents

# California Tick Species

There are 47 species of ticks in California

- Only 8 species bite humans

**“Hard” (Ixodid) ticks**

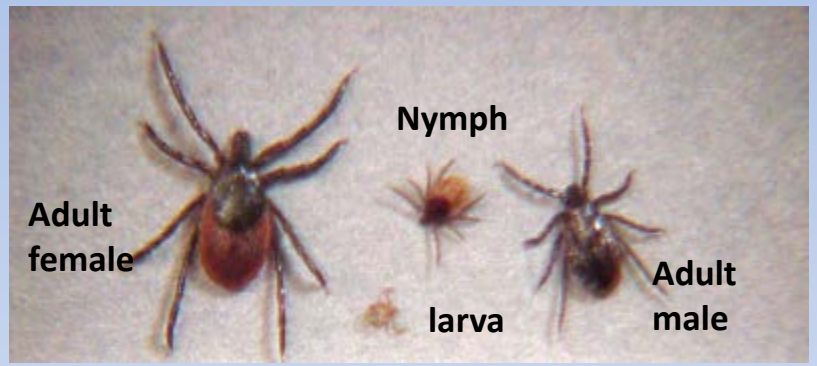
- Western blacklegged tick *(Ixodes pacificus)*
- American dog tick *(Dermacentor variabilis)*
- Pacific Coast tick *(Dermacentor occidentalis)*
- Wood tick *(Dermacentor andersoni)*
- Brown dog tick *(Rhipicephalus sanguineus)*

**“Soft” (Argasid) ticks**

- *Ornithodoros hermsi*
- *Ornithodoros parkeri*
- *Ornithodoros coriaceus*

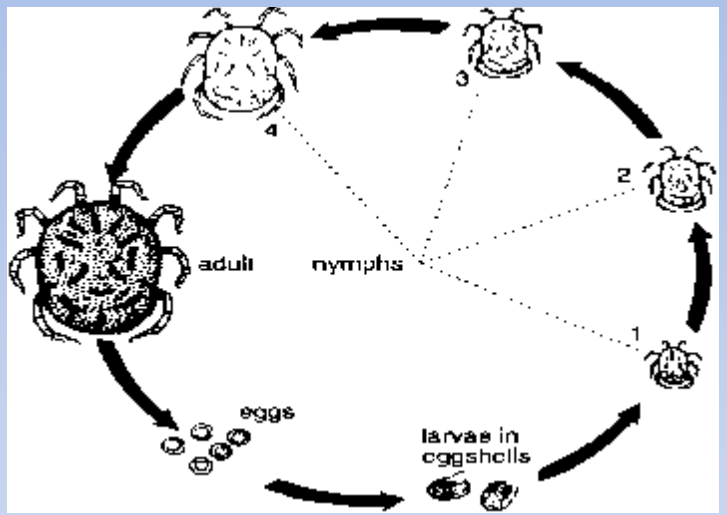
# Tick Life Stages

- Hard ticks




- Hard ticks have a hard outer covering
- Hard ticks have three life stages (larva, nymph, and adult) and feed once per life stage, for days at a time
- Larvae rarely bite humans

- Soft ticks




Source: Unknown

- Soft ticks have a soft outer covering
- Soft ticks have multiple life stages, each life stage may feed several times, for only minutes at a time
- Most patients rarely see or know they have been bitten by a soft tick

# Common Human-Biting Hard Ticks in California

♂ ♀

**Western blacklegged tick**
*Ixodes pacificus*
Vector for Lyme disease and anaplasmosis

**Pacific Coast tick**
*Dermacentor occidentalis*
Vector for Rocky Mountain spotted fever, spotted fever group, tularemia

♂ ♀

♂ ♀

**American dog tick**
*Dermacentor variabilis*
Vector for Rocky Mountain spotted fever, tularemia

**Brown dog tick**
*Rhipicephalus sanguineus*
Vector for Rocky Mountain spotted fever

♂ ♀

# Questing

Most species of hard ticks are found on wild grasses and low plants

Ticks do not fall from trees, jump or fly

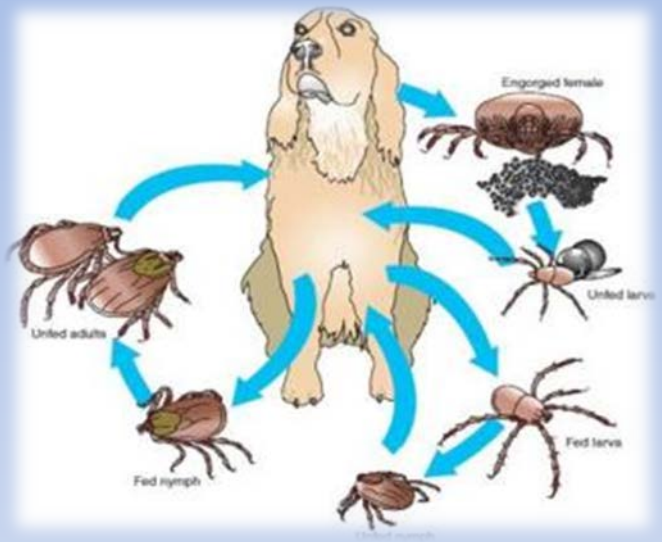
From top to bottom: Pacific Coast tick male, Pacific Coast tick female, western blacklegged tick male

Adult ticks quest by waiting at the ends of grass or other foliage for a host to brush by so they may attach

Two female western blacklegged ticks questing

# The brown dog tick occurs in urban environments, often associated with pets

Ticks questing on blade of grass (above) and pet food dish (below)




Ticks feed on dog, drop off in environment to molt to next life stage, then attach again to dog to feed
Source: https://www.studyblue.com/notes/note/n/ticks/deck/7965547

A dog with brown dog tick infestation on ears and head

A female tick (right) lays thousands of eggs

Brown dog ticks can infest multiple types of urban environments including well-kept yards (above) and kennel areas (left)

# Common Human-Biting Soft Ticks in California

Typical soft tick morphology

**Dorsal – adult female**

Source: insect.com

**Ventral – adult female**

*Ornithodorus hermsii*

- Soft ticks are difficult to detect
  - Patients rarely see them
- Soft ticks are the vector for tick-borne relapsing fever

# Soft Tick Habitat
# (*Ornithodoros hermsi*)

## Rodent nests in the wild

## Rustic dwellings

Click to go table of contents

# Lyme Disease

Western black legged tick (*Ixodes pacificus* )

# *Borrelia burgdorferi*

- Spirochete
  - Host-associated helical bacteria
  - First identified in 1982 by W. Burgdorfer as spirochete*
- *Borrelia burgdorferi* is etiologic agent of Lyme disease in U.S.**
- Lyme disease is the most common vector-borne disease in the U.S.
- In California, *Ixodes pacificus* is the only tick that transmits Lyme disease***

* Burgdorfer et al, 1982. Science (216): 1317-9
** Steere, 2006. Wien Klin Wochenschr. (118): 625-633
***Lane et al. 2004 J. Med Entomol. (41): 239-248

# Symptoms of Lyme Disease

Early Symptoms

- Non-specific “flu-like” symptoms
  - Headache
  - Myalgia
  - Fever
  - Malaise
- Erythema migrans (EM) rash

Later symptoms

- Facial palsy (Bell’s palsy)
- Arthritis in one or more joints
- Rare cardiac involvement

**EM Rash**

Source: Ross Ritter

**Attached tick and reaction**

Source: Lake County HD

# Tick Bites and Lyme Disease

- Erythema migrans (EM) rash
  - EM rash is slowly expanding and sometimes has central clearing
  - Rash typically develops 7-10 days following tick bite (range 1-30 days)
  - Rash is rarely pruritic
    - (Wormser, N Engl J Med 2006;354:2794-801)
  - Reported in ~60% of CA cases

EM Rash

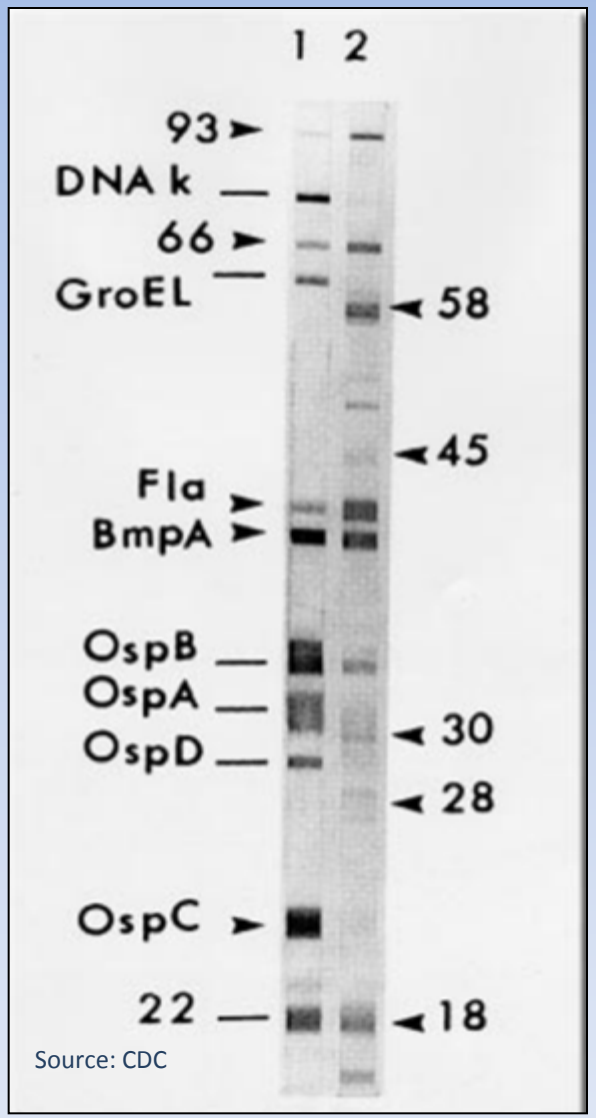
Source: Ross Ritter

- Rash should not be confused with tick-bite lesions (or allergic response)
  - Occurs within 1-24 hrs and does not spread

Source: Lake County HD

# Diagnosis

- Symptoms
  - EM rash, facial palsy
- Exposure potential
  - History of tick-bite or being in tick-infested area
- Serologic test: two-test approach
  - ELISA, IFA, or C6
  - If test positive, follow with confirmatory western blot



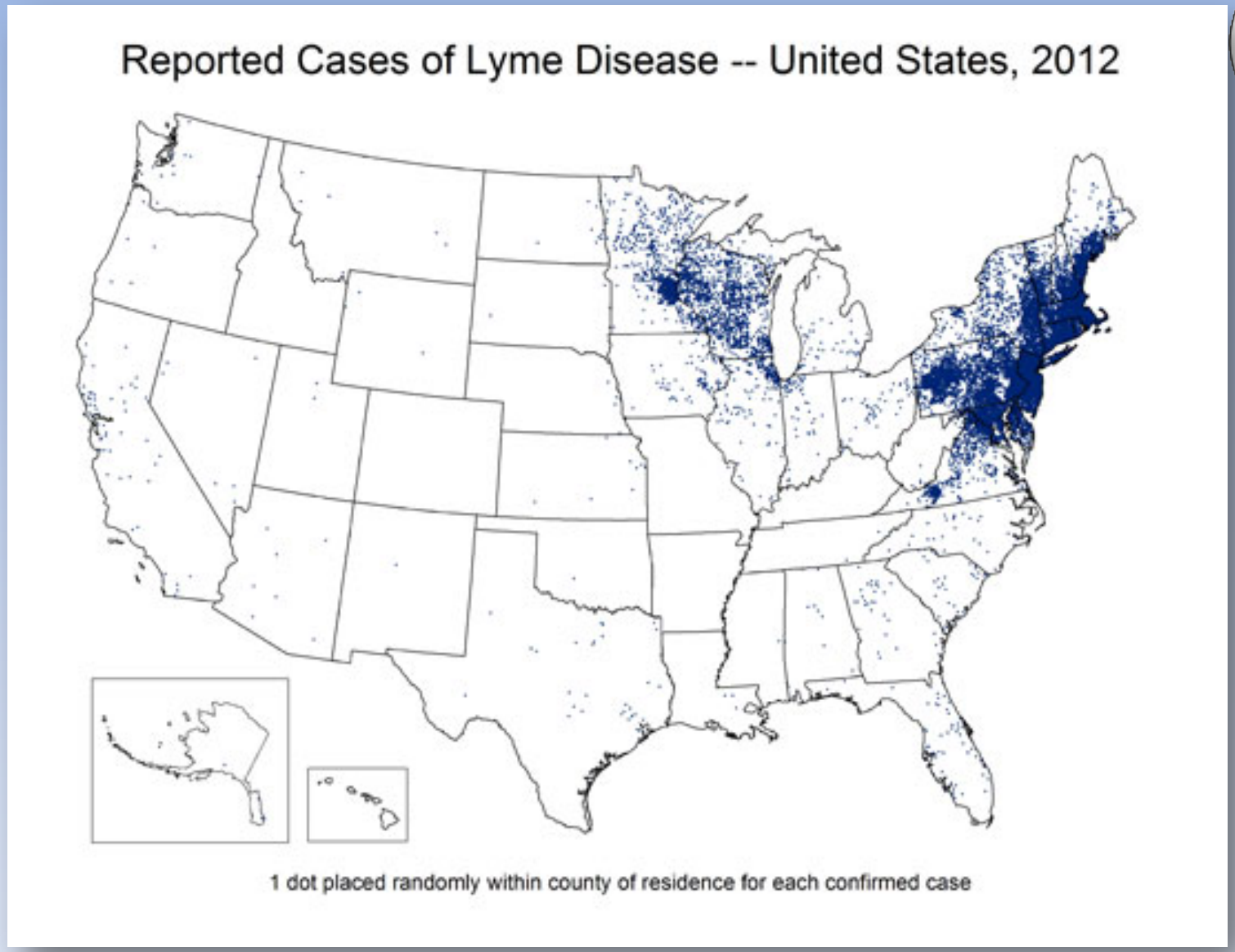
Source: CDC

# Treatment

- Early disease
  - Oral doxycycline
  - Oral amoxicillin
    - For children and pregnant women
- Late and/or neurologic disease
  - Intravenous ceftriaxone
- Slow recovery (i.e. weeks to months) can occur

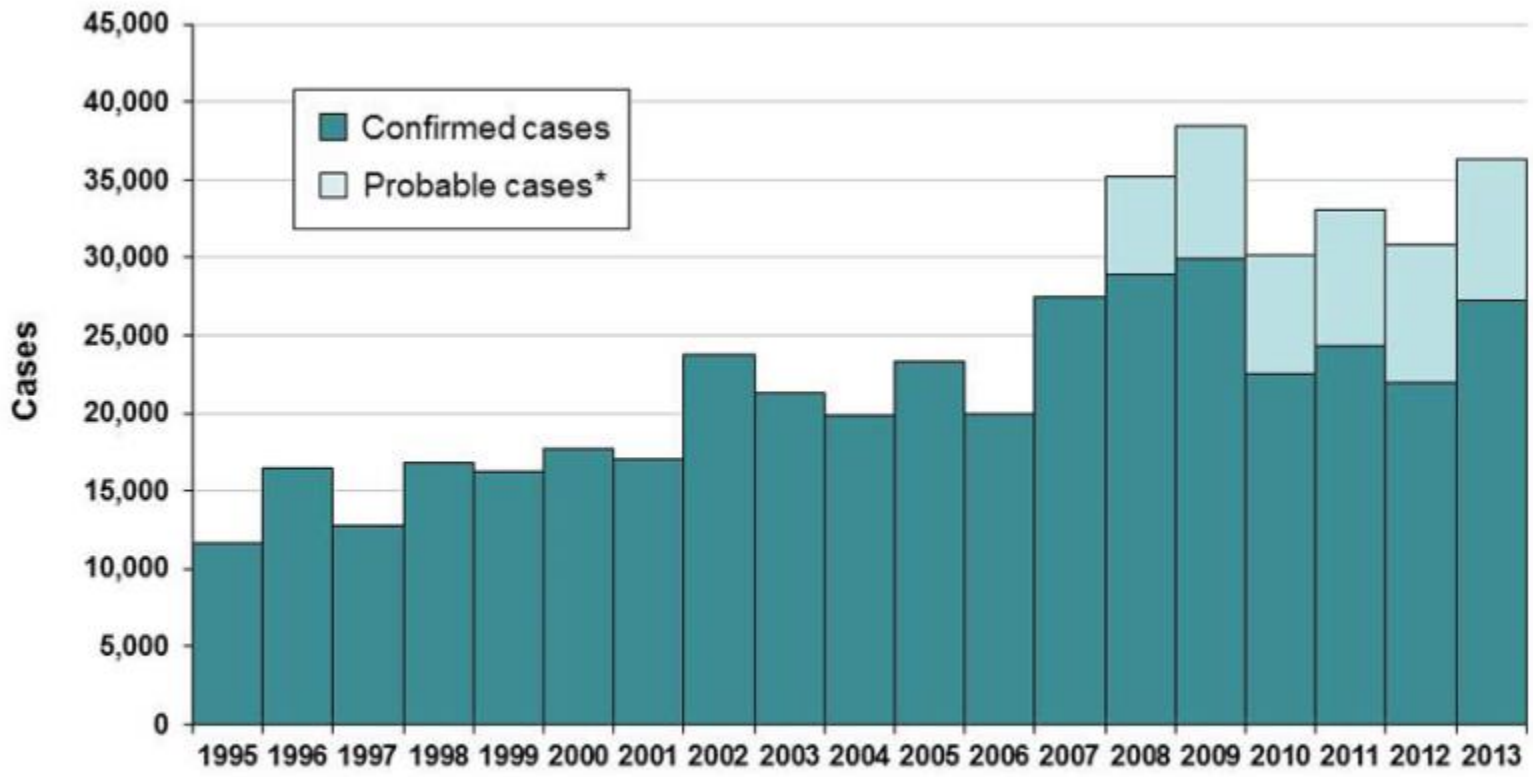
# History of Lyme Disease in California

- First human case identified in 1978 in a hiker from Sonoma County
- Lyme disease became a reportable condition in 1989
  - In 2005, it became laboratory reportable
  - Since 1989, > 2,500 cases of Lyme disease reported through passive surveillance to the California Department of Public Health
- Western blacklegged tick is the only tick that transmits Lyme disease to humans in California



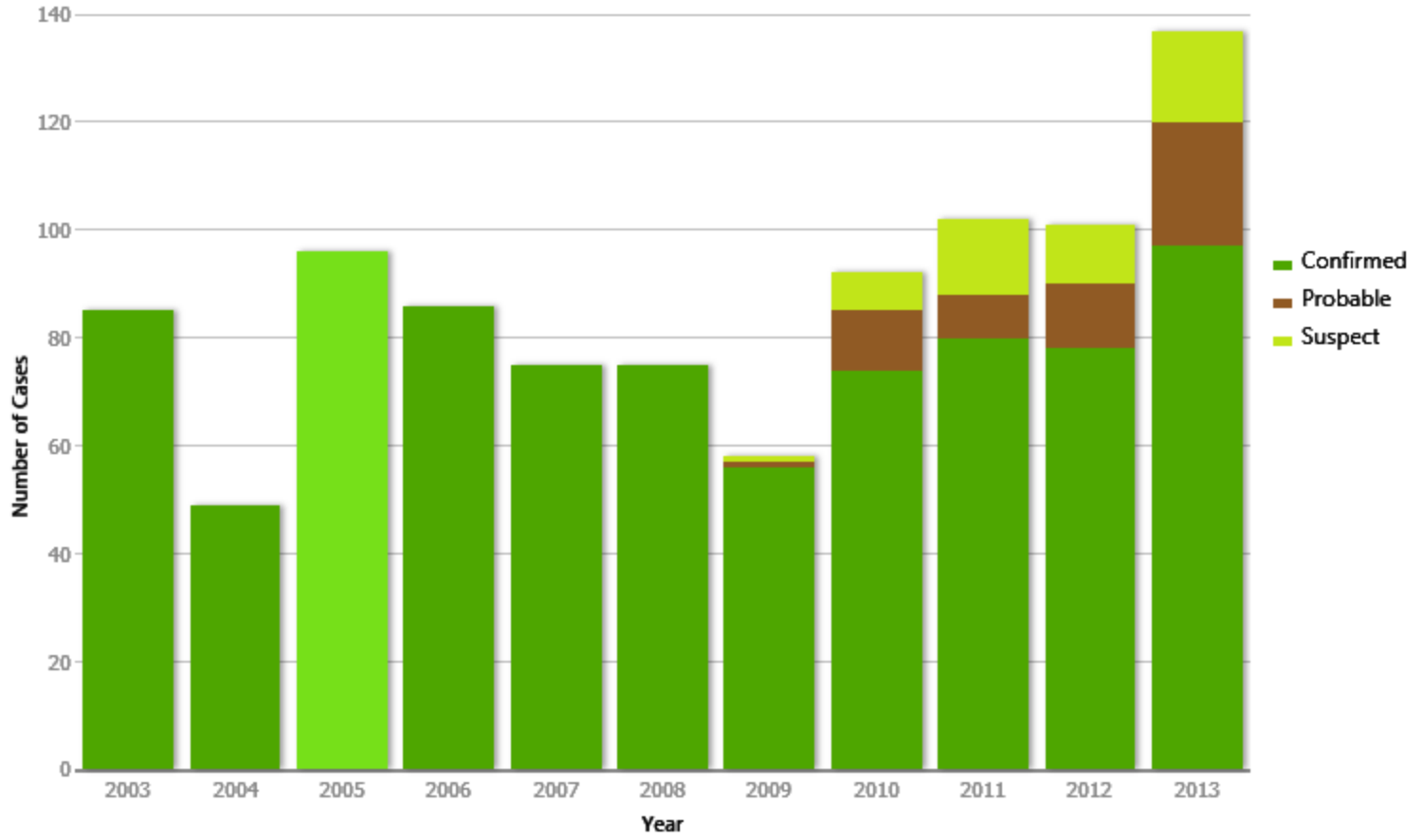

http://www.cdc.gov/lyme/stats/maps/map2012.html

# Reported Cases of Lyme Disease by Year, United States, 1995-2013




*National Surveillance case definition revised in 2008 to include probable cases; details at http://www.cdc.gov/lyme/stats/chartstables/casesbyyear.html

# Reported Cases of Lyme Disease per Year in California



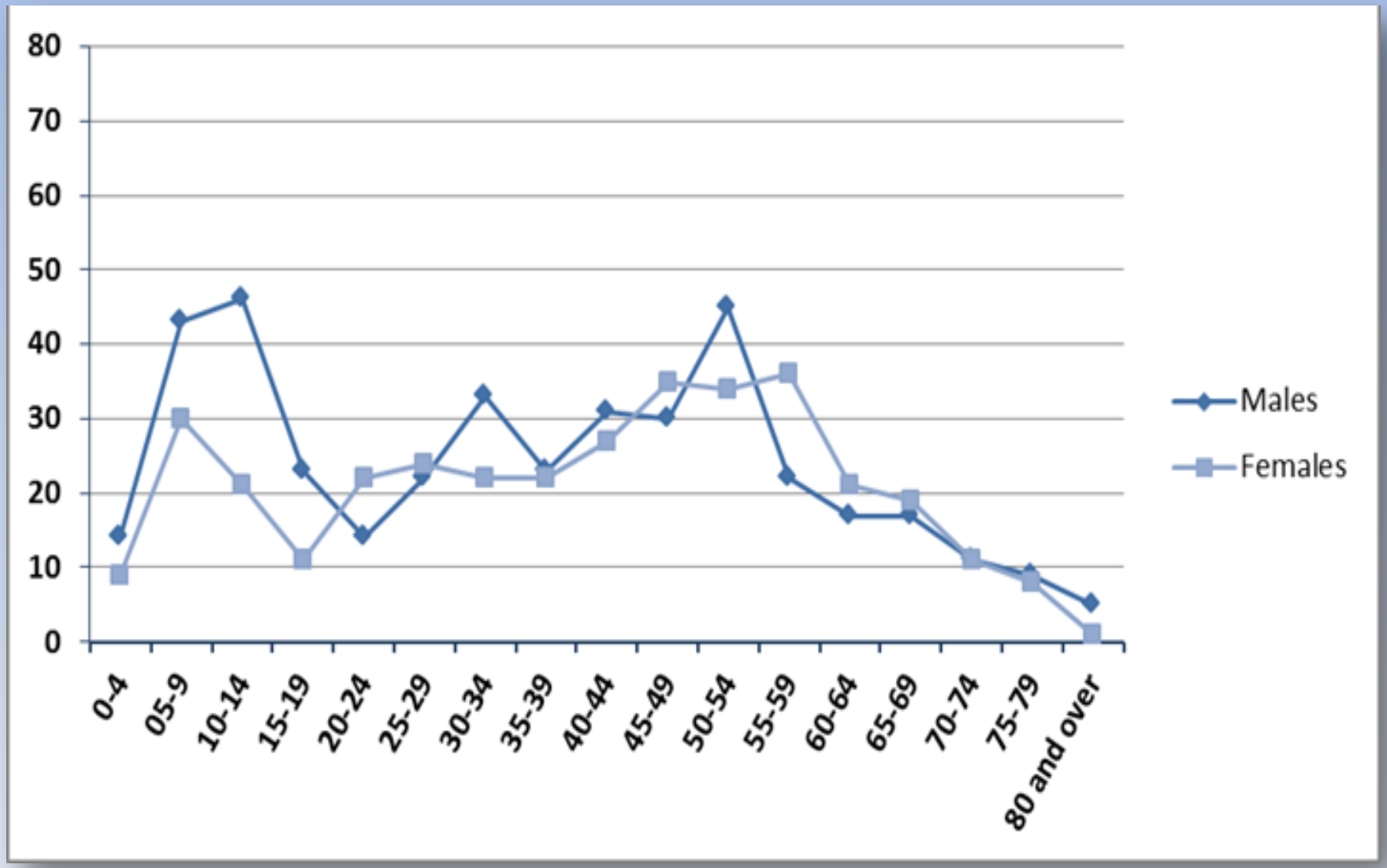
# Reported Incidence of Lyme Disease, California, 2004-2013

**Reported cases per 100,000 person-years**

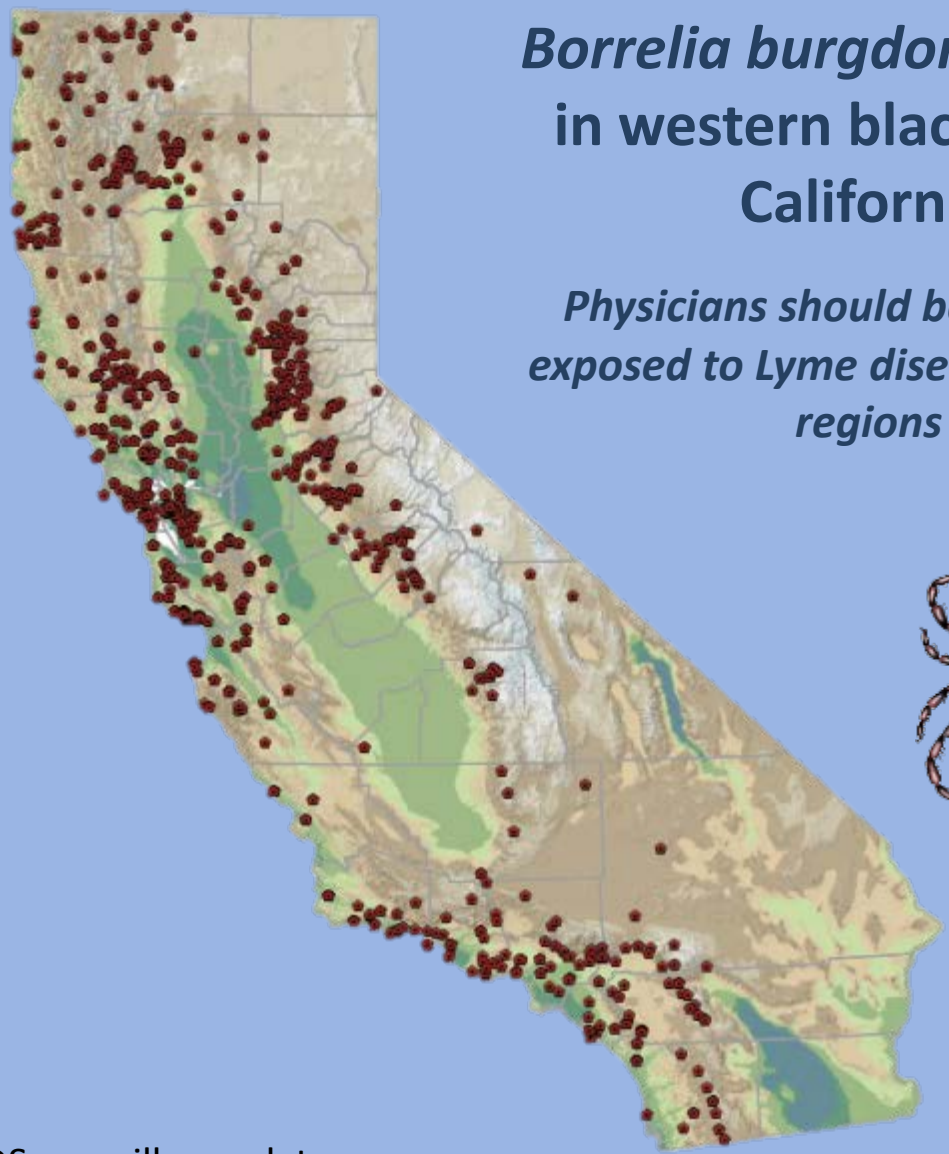
| | | |
|---|---|---|
| Trinity | 5.9 | |
| Humboldt | 4.3 | ≥ 5.0 |
| Mendocino | 4.0 | |
| Sierra | 3.1 | |
| Nevada | 2.4 | 3.0 – 4.9 |
| Mono | 2.0 | |
| Santa Cruz | 1.7 | |
| Mariposa | 1.7 | |
| Amador | 1.6 | 1.0 – 2.9 |
| Sonoma | 1.4 | |
| Marin | 1.0 | |
| Others | | 0.1 – 0.9 |
| No cases reported | | |

- Although Lyme disease cases have been reported in nearly every county, cases are reported based on the county of residence, not necessarily the county of infection.
- The incidence of Lyme disease has remained consistent over the last 20 years
- Northwestern coastal counties are areas of highest risk

# Confirmed Lyme Disease Cases by Age and Gender 2002-2011



# Tick distribution



***Borrelia burgdorferi* has been found in western blacklegged ticks in 42 California counties***

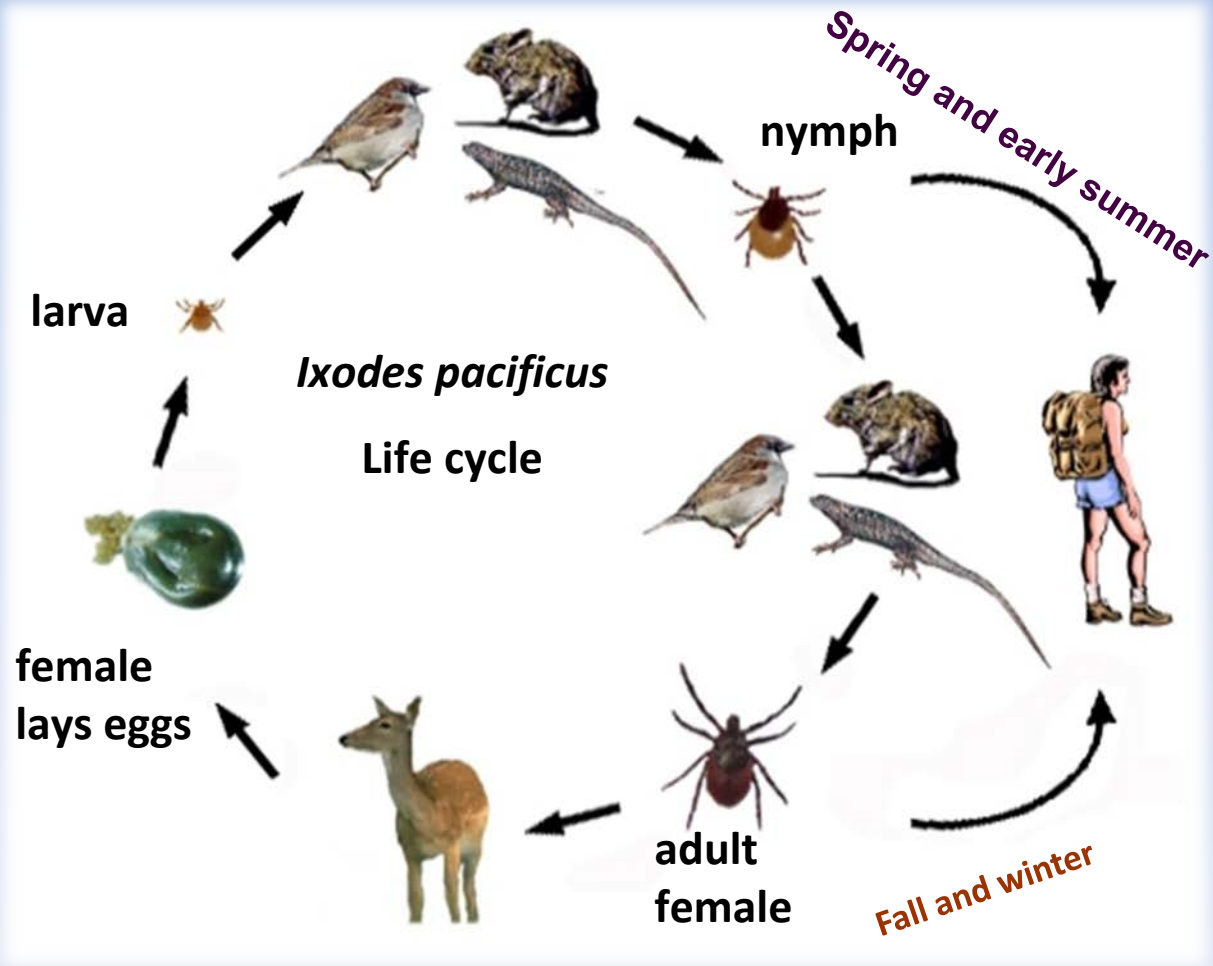
***Physicians should be aware that people can be exposed to Lyme disease-carrying ticks in many regions of California***

**Collection location**

- Tick surveillance has not been conducted in all areas of California; ticks can be found in locations not identified on map.
- Locations where tick surveillance was conducted and no ticks were found are not identified on map.

* VBDS surveillance data

# Transmission of *Borrelia burgdorferi* to Humans in California




Larvae or nymphal ticks acquire the bacteria by feeding on infected mammal hosts

People are accidentally infected through the bite of an infected nymph or adult female western blacklegged tick

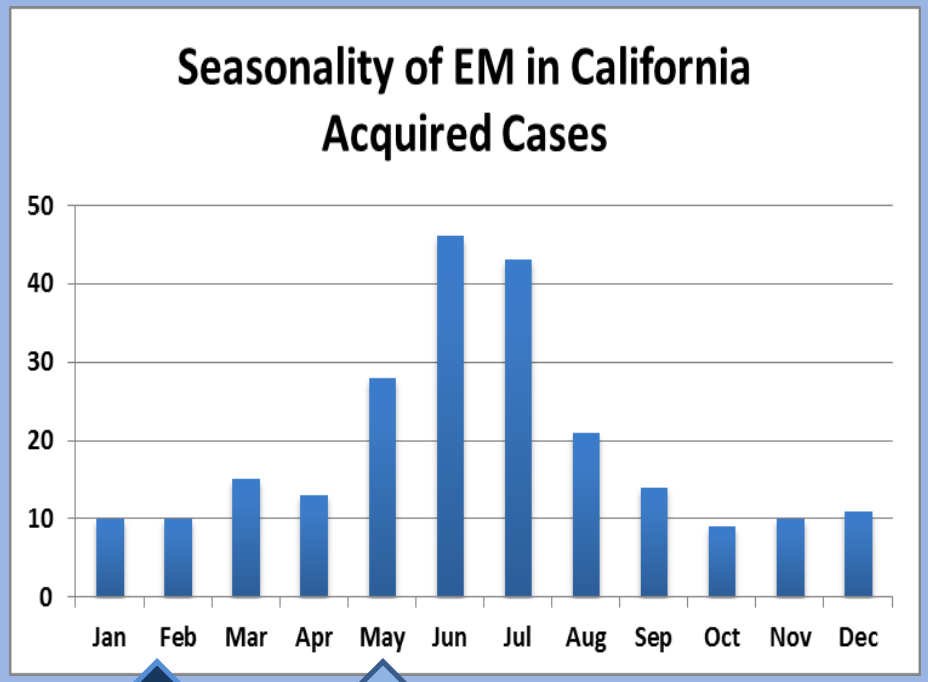
# Western Blacklegged Tick Infection Prevalence with *Borrelia burgdorferi*

- Adult western blacklegged tick: typically 1-5% infected
- Nymphal western blacklegged tick: typically 0-15% infected
  - In northern CA where studied (Mendocino, Placer, Yolo counties), prevalence is often higher in nymphal than adult ticks*
- Larval western blacklegged tick: 0%
  - Larvae rarely bite people

* Clover and Lane 1995. J. Trop Med Hyg. 53: 237-240; Wright et al 1998. J. Med Ent 35: 1044-1049

# Seasonality of Acute Lyme Disease Cases, California 2001-2010

The greatest number of acute cases of Lyme disease acquired in California (as evidenced by EM rash) occurs in June, one month after the peak nymphal tick season




**Approximate peak adult western blacklegged tick season**

**Approximate peak nymphal western blacklegged tick season**

# Nymphal Tick Exposure Risk by Habitat

Grassland (very low)

Chaparral (low)

Woodland-grass (low)

Dense woodland (≥moderate)

Slide courtesy R. S. Lane

# California: Lizards and Lyme Disease

Western fence lizard

Alligator lizard

Nymphal and larval ticks on a western fence lizard

- Nymphal western blacklegged ticks feed on lizards
- A borreliacidal protein in lizard blood kills *Borrelia burgdorferi* spirochetes in the gut of infected nymphal ticks*
- As a result, in some areas in California, the proportion of infected adult western blacklegged ticks is lower than in the nymphal western blacklegged ticks

  -The blood meal from the lizard “cleaned” the tick

*Lane and Quistad 1997. J. Parasitol. 84: 29-34

# To find out more about Lyme disease in California,
## visit the CDPH website at:

http://www.cdph.ca.gov/healthinfo/discond/Pages/LymeDisease.aspx

Click to go table of contents

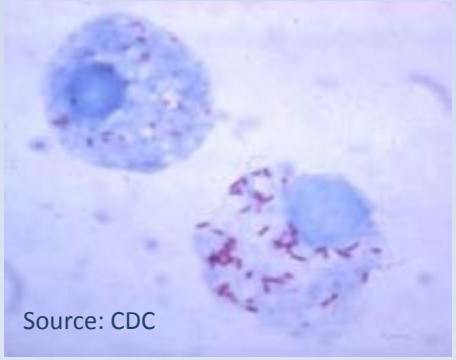
# Spotted Fever Group *Rickettsia* including: Rocky Mountain spotted fever ( *Rickettsia rickettsii*)

Source: CDC

American dog tick (*Dermacentor variabilis*)

# Spotted Fever Group Rickettsia: *Rickettsia rickettsii* and *Rickettsia* 364D

- Genus *Rickettsia* is in bacterial tribe *Rickettsieae*, family *Rickettsiaceae*, and order *Rickettsiales*
- Related to *Ehrlichia* and *Anaplasma*
- All intracellular pathogens
- Called "spotted fever group" due to the rashes typically seen with these infections


Source: CDC

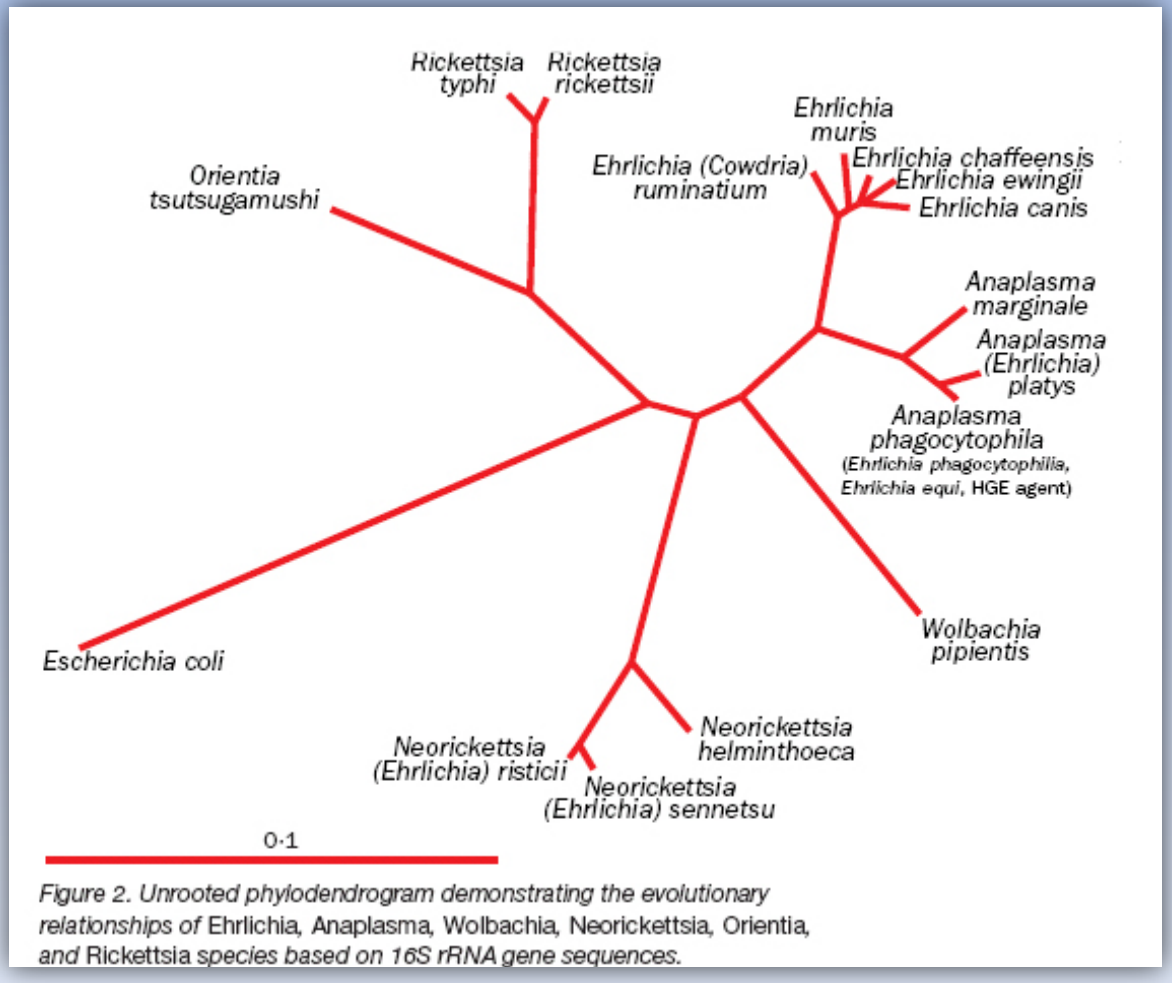
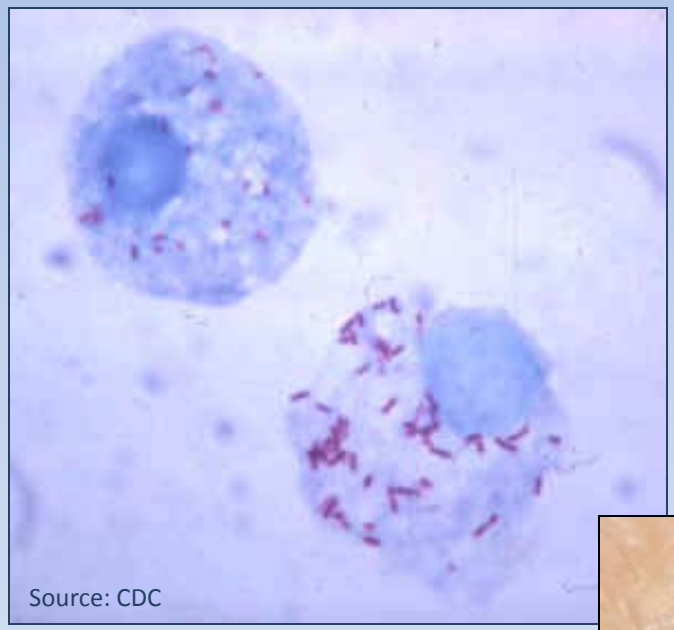


*Figure 2. Unrooted phylodendrogram demonstrating the evolutionary relationships of* Ehrlichia, Anaplasma, Wolbachia, Neorickettsia, Orientia, *and* Rickettsia *species based on 16S rRNA gene sequences.*

Dumler and Walker, 2001; Lancet Infectious Diseases; April 21-28

# Rocky Mountain Spotted Fever


Source: CDC

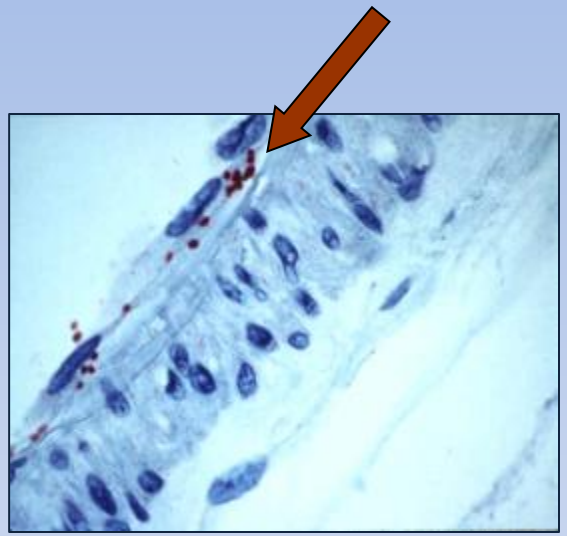
Source: CDC

# Rocky Mountain Spotted Fever (RMSF)

- Most severe tick-borne illness in the United States
  - 3-5% case fatality if treated
  - 20% case fatality if untreated*
  - Recent studies suggest case fatality has decreased to as low as 0.5%
    - Higher risk of fatality in children 5-9 years**
    - Most cases occur during summer months

- Primary California tick vectors
  - American dog tick (*Dermacentor variabilis*)
  - wood tick (*Dermacentor andersoni*)

- Family Rickettsiaceae
  - *Rickettsia rickettsii*
  - Small, intracellular bacteria



*Rickettsia rickettsii* in endothelial cells of a blood vessel from a patient with fatal RMSF
Source: CDC

* Chapman et al., MMWR Recomm Rep 55: 1 – 27
**Openshaw et al., Am. J. Trop. Med. Hyg., 83(1), 2010, pp. 174–182

# Clinical Features of RMSF

- Sudden fever, myalgia, nausea, headache
  - 2 to 14 days after tick bite
- Rash (81%-91% of patients*)
  - Usually 3 to 5 days after tick bite
  - Starts as blanching macular rash
    - Eventually become papular**
  - Often on palms and soles (36-82% cases)*
  - Often spreads to entire body
  - The later the rash appears, the higher the mortality*
- Thrombocytopenia
  - Leads to severe complications
    - Acute respiratory distress syndrome (ARDS), abdominal pain, neurologic or bleeding disorders, loss of circulation (gangrene)

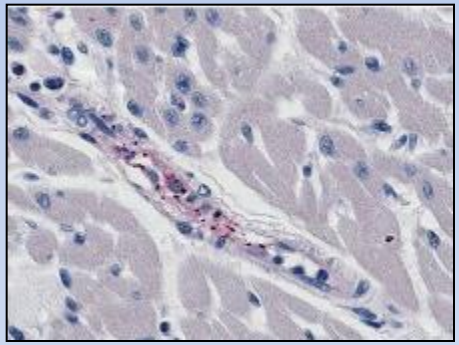
Source: CDC

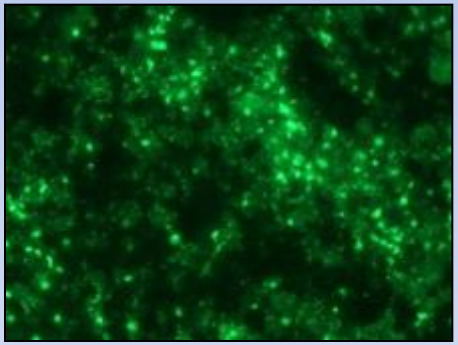
* Mandell et al, Principals and Practices of Infectious Diseases, 2005 pp 2288-2293

**CDC Rocky Mountain Spotted Fever: http://www.cdc.gov/ncidod/dvrd/rmsf/Signs.htm

# Diagnosis and Treatment

- Diagnosis
  - Serology
    - Rising antibody titers (four-fold change in acute and convalescent samples)
    - IFA or ELISA tests
  - PCR, immunohistochemical staining of tissue (difficult to obtain), culture





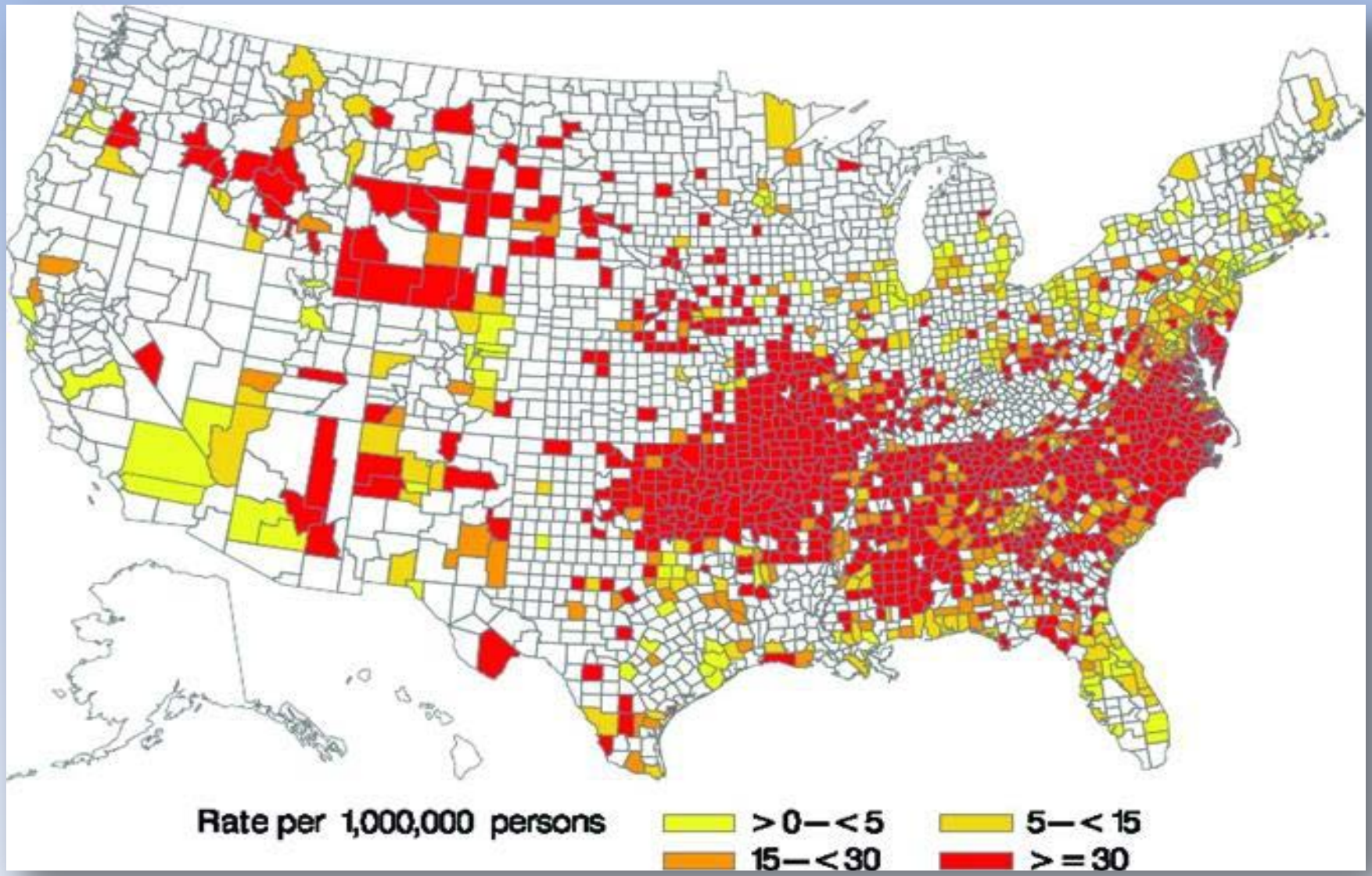
Source: Centers for Disease Control and Prevention

- Treatment
  - Doxycycline
    - Adults <u>and</u> children (not pregnant women)*

***<u>Do not wait for diagnosis – must treat on suspicion!</u>***

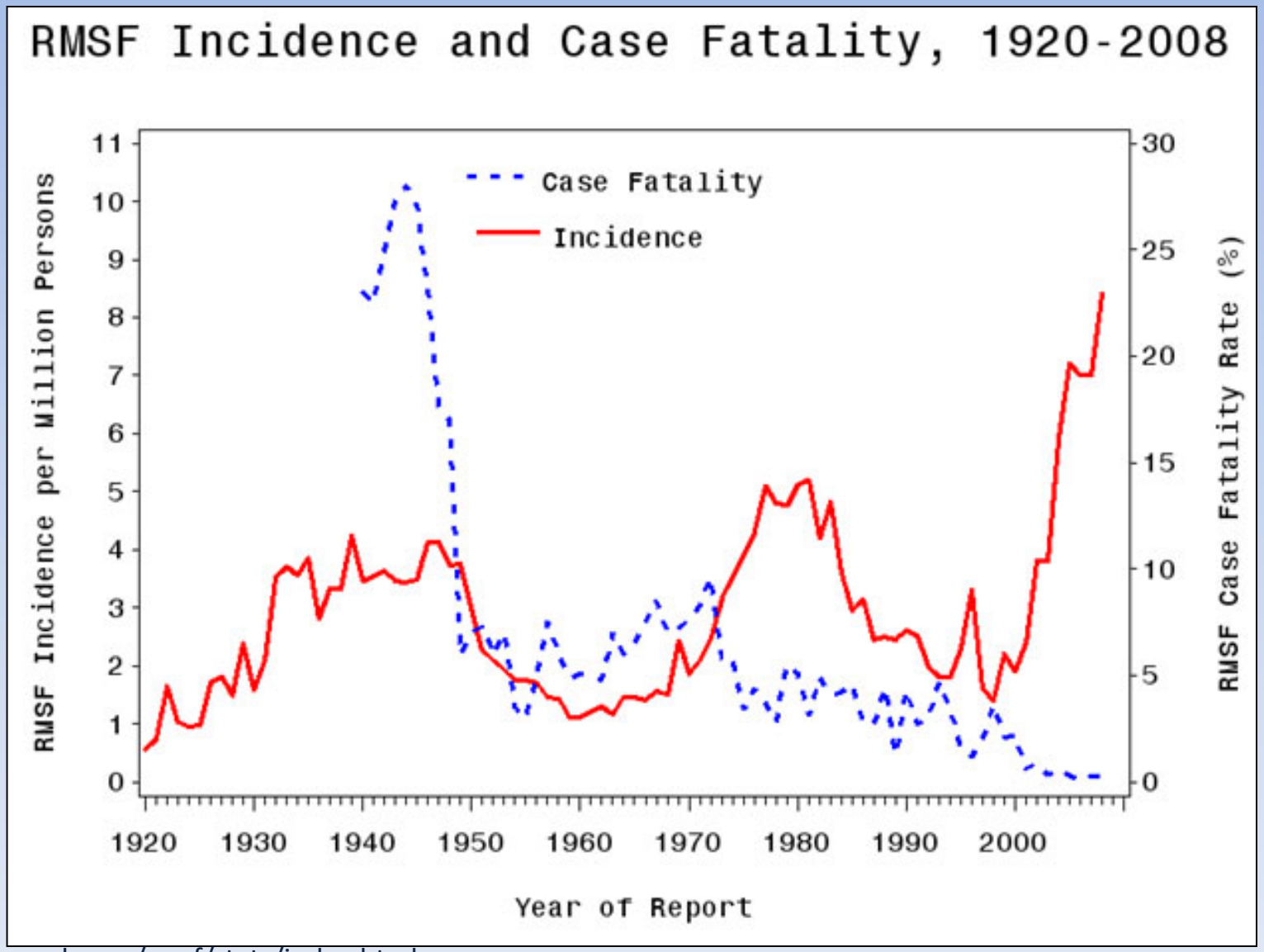
* Mandell et al, Principals and Practices of Infectious Diseases, 2005 pp 2288-2293

# Annual Reported Incidence for Rocky Spotted Mountain Fever in the United States, 2000-2007



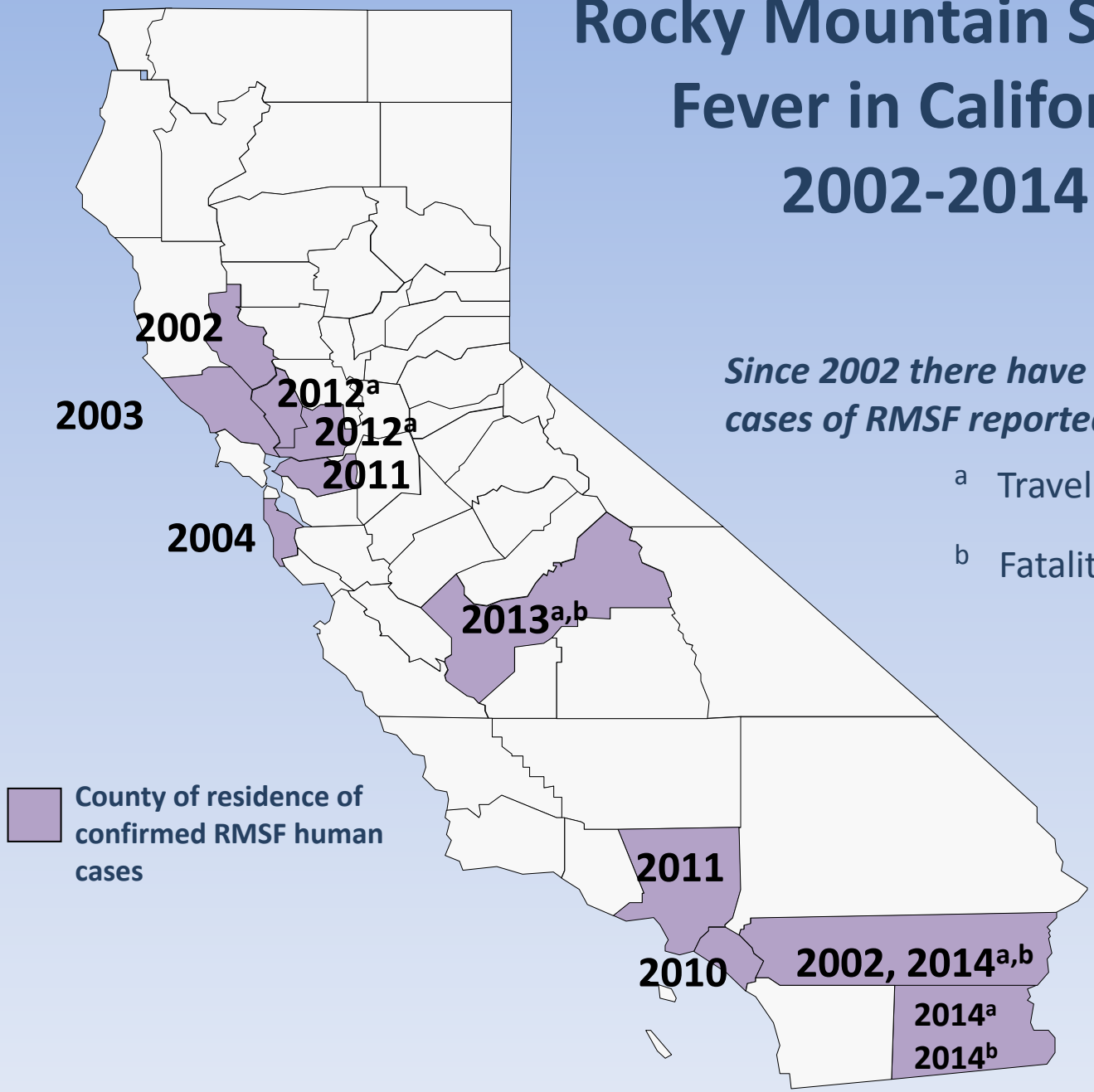

Openshaw et al., Am. J. Trop. Med. Hyg., 83(1), 2010, pp. 174–182

# Reported Incidence and Case Fatality of Rocky Mountain Spotted Fever in the United States, 1920-2008




http://www.cdc.gov/rmsf/stats/index.html

# Rocky Mountain Spotted Fever in California 2002-2014



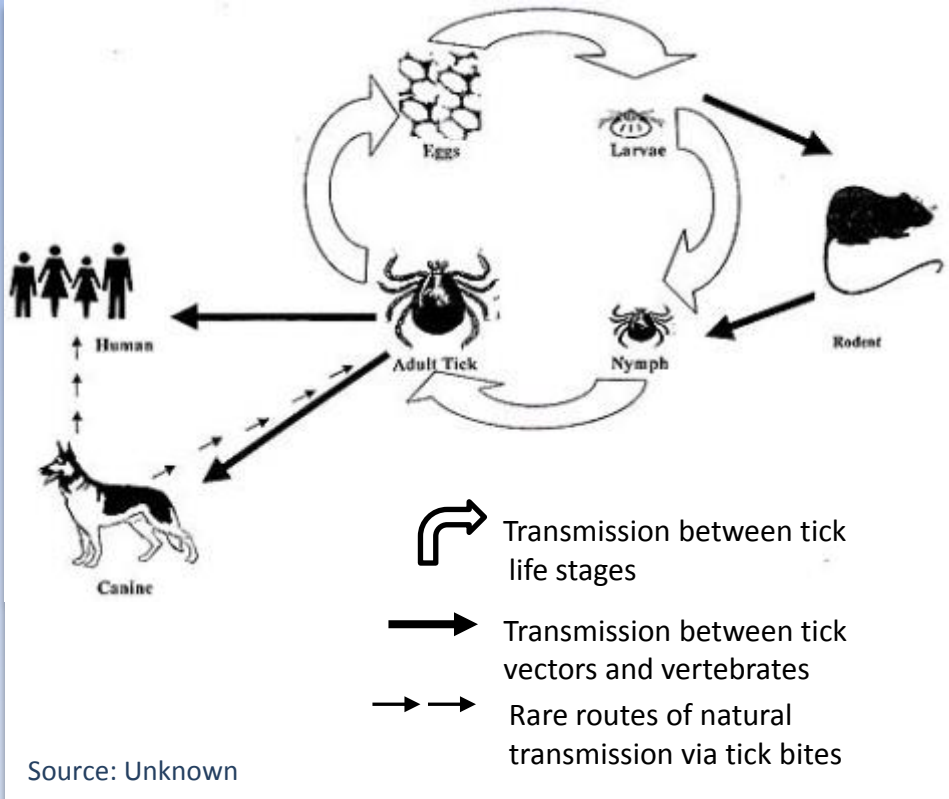

***Since 2002 there have been 13 confirmed cases of RMSF reported in California***

[a] Travel history out of county

[b] Fatality

# Tick-Pathogen Cycle

- Ticks acquire infection by feeding on infected mammal (such as chipmunk, squirrel, dog)
- Ticks maintain and pass on infection between life stages (transstadial) and through eggs to larvae (transovarial)
- Ticks function as both reservoir and vector
- Ticks require 6-20 hours of feeding to transmit Rickettsiae
  - Shorter transmission time than for other tick-borne diseases




Source: Unknown

# Ticks Associated with RMSF Transmission and Distribution in California

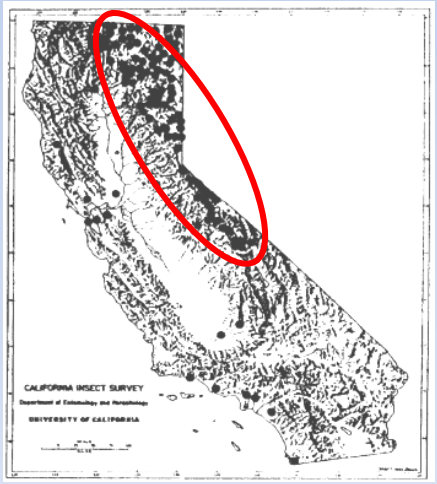
Source: CDC

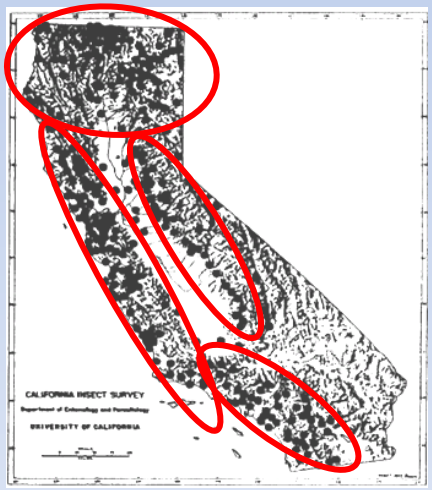
**Wood tick**
***Dermacentor andersoni***

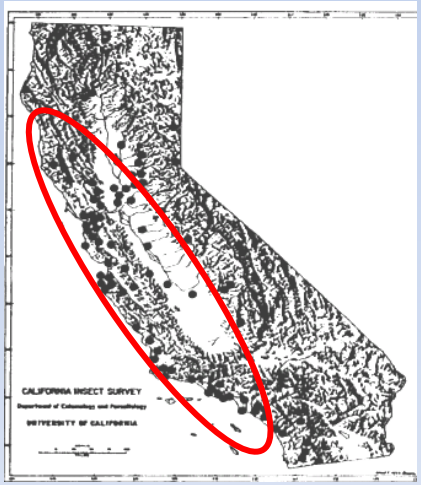
**Pacific Coast tick**
***Dermacentor occidentalis***

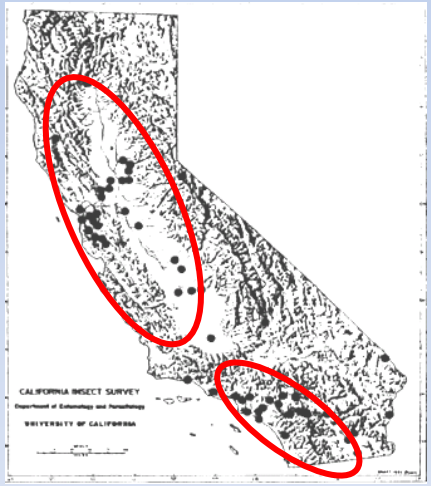
**American dog tick**
***Dermacentor variabilis***

**Brown dog tick**
***Rhipicephalus sanguineus***




**Red circles generalize tick species distribution**

**The Ticks of California, by D. Furman and E. Loomis, 1984**

Source: CDC

# American Dog Tick
# *(Dermacentor variabilis)*

- Primary vector of RMSF in southeastern states
- Common tick in California
- Adult tick preferred host
  - large and medium-sized mammals including domestic dog
  - Often bites humans
- Immature stages preferred host
  - small rodents

Source: CDC

**Range of *D. variabilis* in the US**

Source: CDC

# Rocky Mountain Wood Tick *(Dermacentor andersoni)*

- Vector for RMSF in Rocky Mountain region
- Adult tick feeds on large domestic and wild mammals and also bites humans
- Immature stages feed on rodents

Source: CDC

**Range of *D. andersoni* in the US**

Source: CDC

# Brown Dog Tick (*Rhipicephalus sanguineus*)

- Historical and known vector in South America
- Recently implicated in the U.S. as primary vector in two recent RMSF outbreaks
  - Eastern Arizona 2003 - current
  - Mexicali outbreak 2008 - current
- *R. sanguineus* appears to be predominant vector of RMSF in the southwest U.S.
- Continued environmental and dog-targeted tick control necessary to prevent continued transmission

Source: CDC

**Range of *R. sanguineus* in the U.S.**

# Other Spotted Fever Rickettsiae

# Tick-Borne Spotted Fever Rickettsiae in the United States

- In addition to *Rickettsia rickettsii* (RMSF), several other tick-borne species of Rickettsiae, “spotted fever group *Rickettsia*" have been shown to cause human infections
- Spotted fever group *Rickettsia* are transmitted to humans by the bite of an infected tick
  - May cause similar signs and symptoms to those observed for RMSF
- Pathogens in the U.S. include several species of *Rickettsia*
  - *Rickettsia parkeri*
    - Transmitted by *Amblyomma maculatum* (Gulf Coast tick)
    - Eastern and southern U.S., particularly along the coast
  - *Rickettsia* species 364D (*Rickettsia philipii*)
    - Transmitted by *Dermacentor occidentalis* (Pacific Coast tick)

# *Rickettsia philipii*

- Originally described as "*Rickettsia* 364D"
- First detected in ticks in 1966 in California
- To date, detected in Pacific Coast ticks (*Dermacentor occidentalis*) ticks only
- First human case from Lake County, California July 2008
- Common sign includes a local cutaneous eschar (dark crusted ulcer)
- Treated with doxycline

Eschar on forearm

Eschar on arm

# *Rickettsia philipii*
# Clinical Case Summary 2008 - 2013 (n=12)

- Proposed clinical name: Pacific Coast Tick Fever
- Clinical
  - Fever 92%
  - Headache 90%
  - Lymphadenopathy 46%
  - Eschar 100%
    - some multiple, at least one with petechial rash
  - Only 3 with recalled tick bite
- Lab
  - Often low white blood cell count
  - Thrombocytopenia
  - Liver function transaminases (LFTs) sometimes mild abnormal

# Challenges for Diagnosing

– Many “look-alikes”

Tick-bite reaction

Source: Mariposa Environmental Health

Cutaneous anthrax

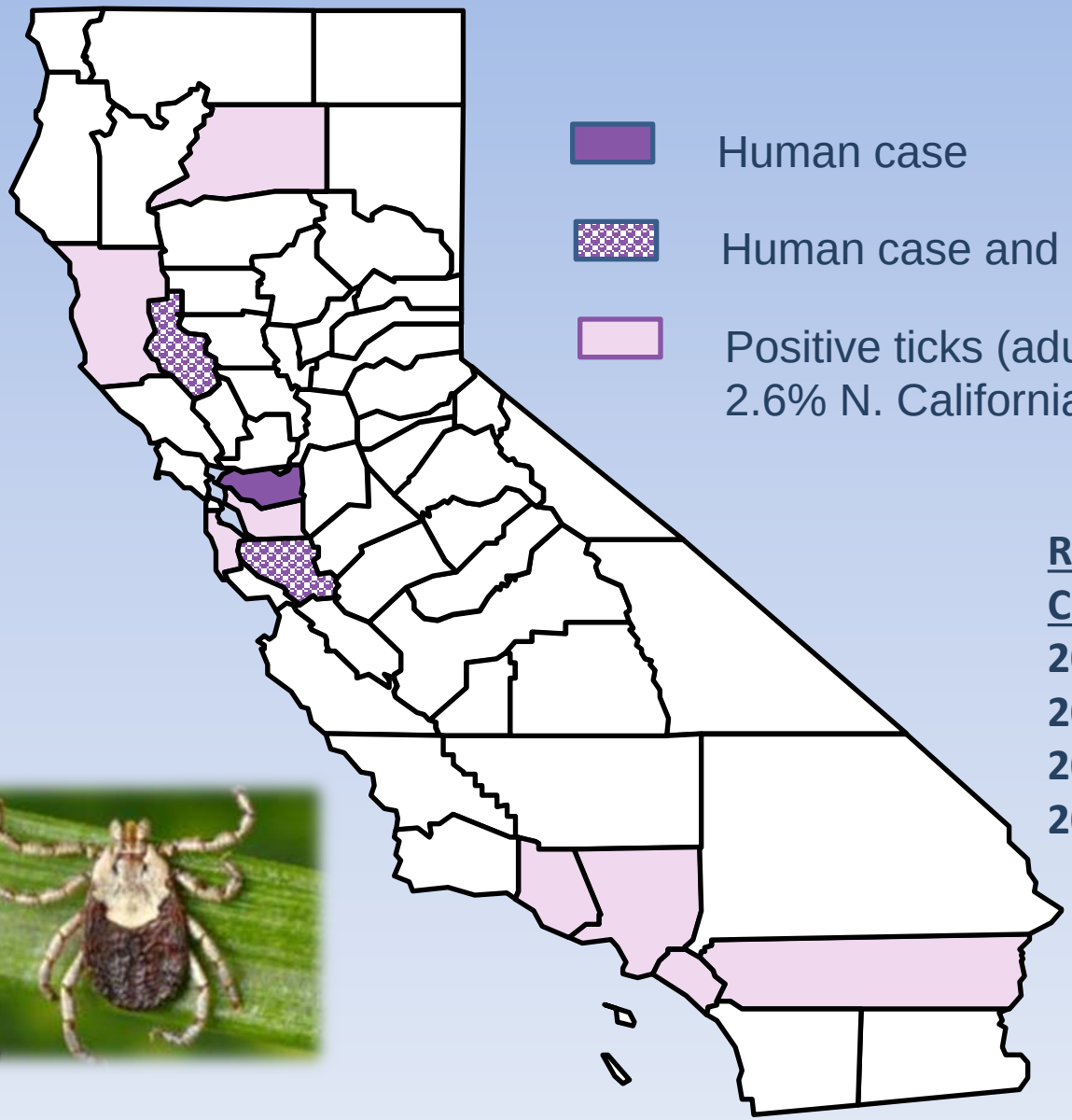
Source: CDC.gov

Source: http://www.textbookofbacteriology.net/Anthraxlesion.gif

Parapox virus

Source: Colorado State University Extension

# Distribution of *Rickettsia philipii* Cases and Infected Ticks in California



Human case

Human case and positive ticks

Positive ticks (adult Pacific Coast ticks: 2.6% N. California; 6% S. California)

**Reported Human Cases in California**

**2013: 3 cases**
**2012: 4 cases**
**2011: 5 cases**
**2008: 1 case**

# If You Identify A Suspect *Dermacentor* Tick-Bite Associated Eschar:

- Submit whole blood sample for Spotted Fever Group *Rickettsia* testing to CDPH, Viral and Rickettsial Disease Laboratory (VRDL; add details/contact) at time of identification and convalescent sample 3-4 weeks later
- Collect two samples from wound under eschar with dry cotton swabs, store in vials, send to VRDL for PCR

California Department of Public Health – July 2012

## Laboratory Testing for Spotted Fever Rickettsiosis

A newly described eschar-associated illness has been identified in California caused by Spotted Fever Group (SFG) *Rickettsia* 364D and transmitted with tick bite. The most prominent clinical feature of *Rickettsia* 364D infection is the development of an isolated ulcer with raised erythematous margins and core black eschar, usually with surrounding generalized edema and erythema, which develops 3-14 days at the site

**Specimen collection:**

**Minimum specimen requirement:** Paired serum specimens. Sera (5-10 cc) should be collected in a red top or tiger top tube.

- Acute serum should be taken in the 1st week of illness (or within ~7-10 days post onset)
- Convalescent serum should be taken at least

http://www.cdph.ca.gov/programs/vrdl/Pages/WhatsNew.aspx

To find out more about spotted fever group Rickettsiae in California, visit the CDPH website at:

http://www.cdph.ca.gov/HealthInfo/discond/Pages/TickBorneDiseases.aspx

Click to go table of contents

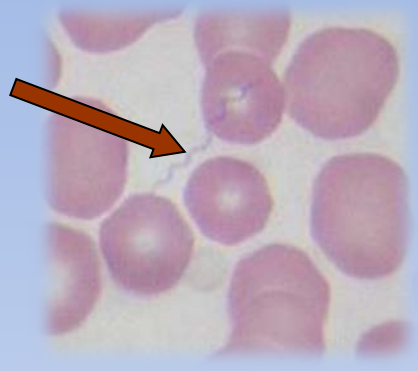
# Tick-Borne Relapsing Fever

*Ornithodoros hermsi*

# Tick-borne Relapsing Fever (TBRF)

**Agent**

- *Borrelia hermsii*, *B. parkerii, B. turicatae*
- Visible on stained red blood smear



Source: Gary Green, M.D., Sonoma Co.

**Vector**

- Soft (Argasid) ticks, *Ornithodoros* spp.
- In U.S., *O. hermsi*, *O. parkeri, O. turicata*
- Transmitted from infected female tick to her progeny (transovarial transmission) and from one life stage to next (transtadial transmission)

**Reservoir**

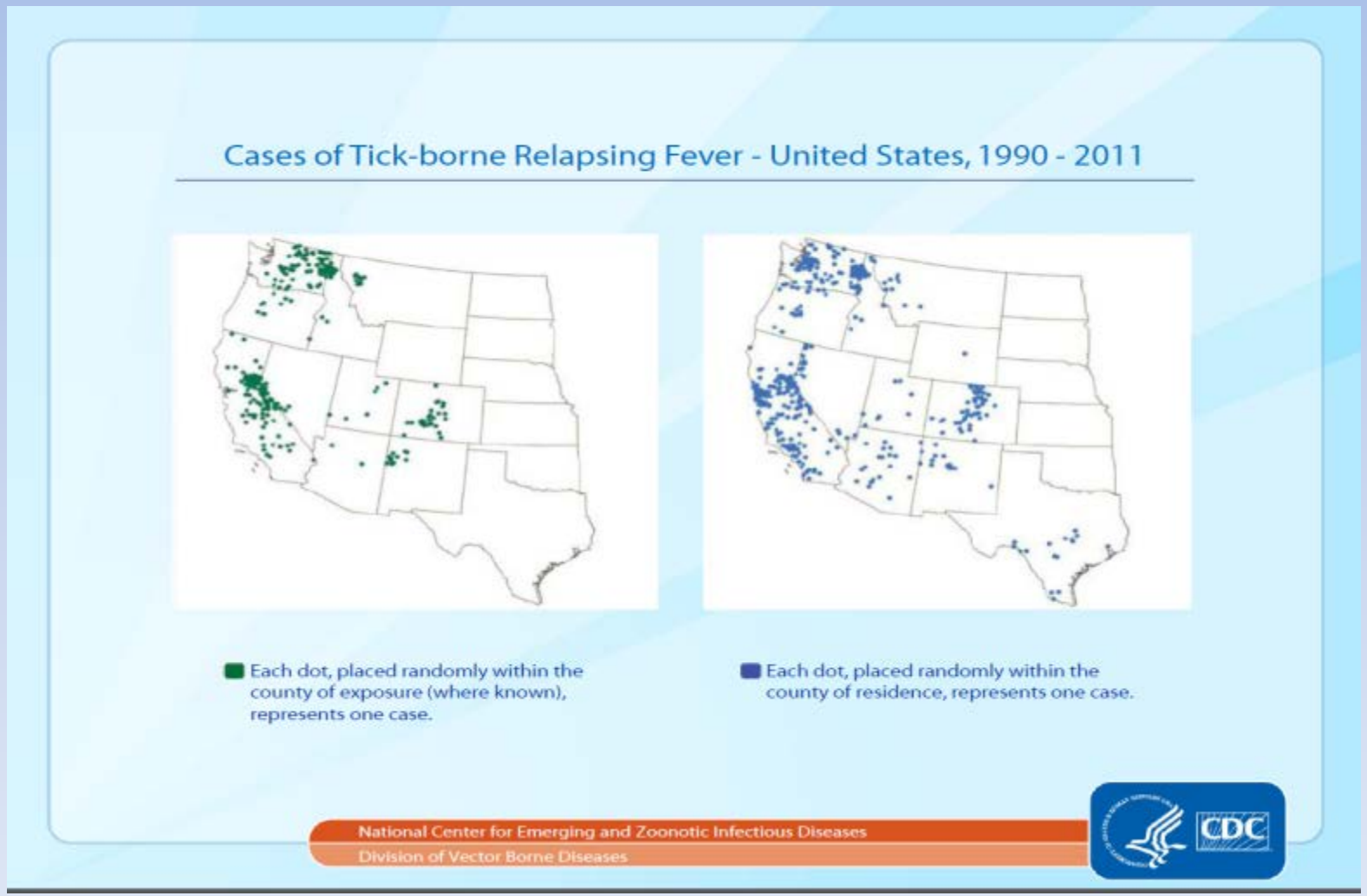
- Peridomestic rodents
  - Chipmunks, squirrels, rats, mice
- Infected animals carry the organism in their blood
- A soft tick acquires infection when they take a blood meal from an infected animal

# Tick-borne Relapsing Fever

- TBRF is a serious disease
  - However, if treated the case fatality rate is less than 5%
  - If acquired during pregnancy, TBRF poses a high risk of fetal loss (up to 50%)
- Symptoms
  - Incubation period: 1 to 14 days
  - Fever, headache, chills, myalgia
  - Febrile episodes 1 to 7 days separated by afebrile periods of 1 to 5 (up to 20) days
  - Up to 10 relapses

http://www.cdc.gov/relapsing-fever/clinicians/

# Reported Cases of Tick-borne Relapsing United States




http://www.cdc.gov/relapsing-fever/resources/CasesTBRF.pdf

# Tick-borne relapsing fever in California
# 10 year summary: 2005-2014

- 53 cases over last 10 years
- Median of 5 cases each year (range = 1 - 11)
- Case age range from 1 to 79 years
  - Median 36 years
  - Males more than females (30 to 23)
- Most cases contracted in summer months
  - June to September
- Most frequent counties of exposure (all in the Sierra mountain range)
  - Mono > El Dorado > Nevada > Inyo > Fresno

CDPH Internal Data

# Tick-borne relapsing fever in California, 1997 – 2014*

The majority of TBRF cases in California are acquired in mountainous regions

* CDPH surveillance data

# Tick-borne Relapsing Fever Exposure

- High risk sites:
  - Rodent-infested cabins 3000 - 9000 feet elevation
  - coniferous forest
- Soft ticks live in rodent nests in building
  - Seek out blood meal when rodents vacate nest
  - Humans vulnerable when sleeping on floor or in beds in contact with walls

# Tick-borne Relapsing Fever Exposure

Cabins in northern California where TBRF cases were exposed

In the United States, TBRF exposure most often occurs in a rustic cabin where rodents have made their nests

# Preventing Tick-borne Relapsing Fever

- Prevent rodent infestations of dwellings

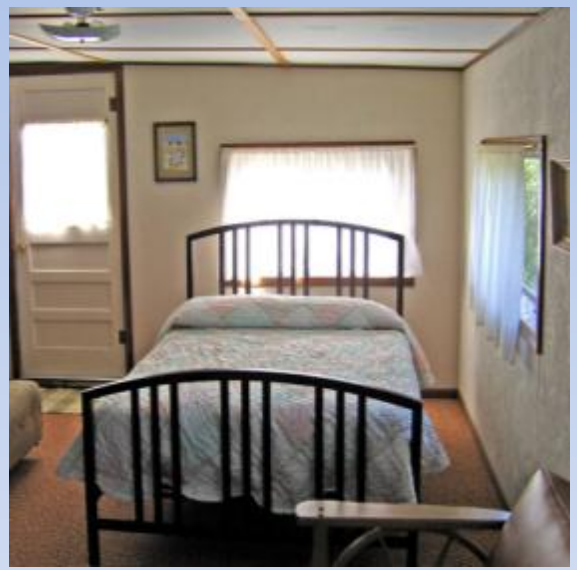
- Discourage feeding of chipmunks and squirrels

- Store firewood away from dwelling

# Preventing Tick-borne Relapsing Fever

- Keep beds away from walls

- Removal of rodents from structure without ectoparasite control may increase disease potential
  - chemicals may not penetrate cracks in walls
  - attempt to identify and remove rodent nests

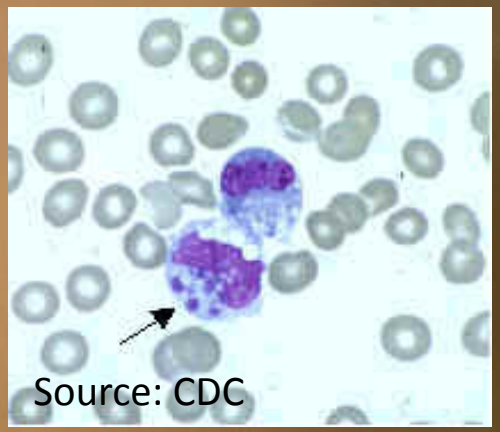


To find out more about tick-borne relapsing fever in California,
visit the CDPH website at:

http://www.cdph.ca.gov/HealthInfo/discond/Pages/TickBorneRelapsingFever.aspx

Click to go table of contents

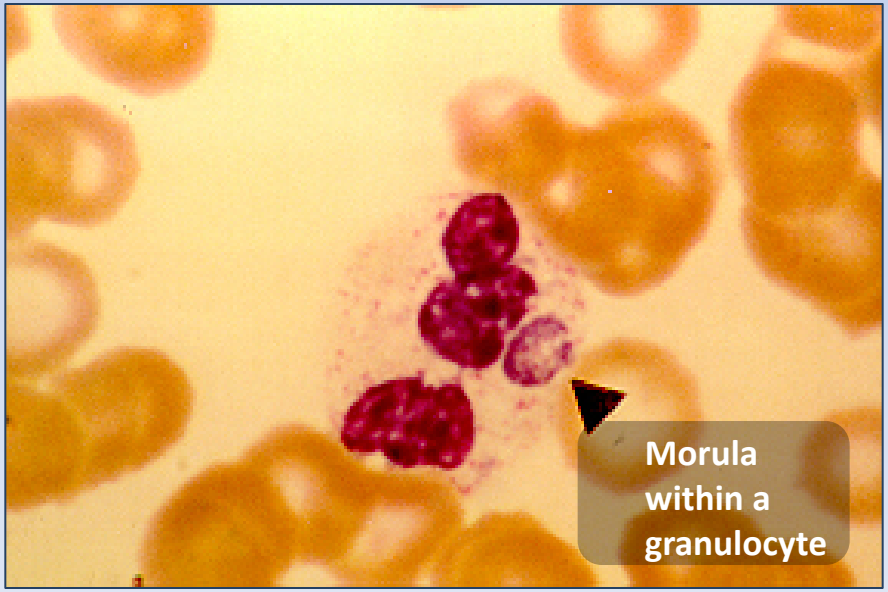
# Anaplasmosis




Western blacklegged tick (*Ixodes pacificus* )

# Anaplasmosis

- Small gram negative bacteria
  - Invade and replicate inside granulocytes (neutrophils)
  - Colonies inside granulocytes are called morula
  - Organism called *Anaplasma phagocytophilum*
- Disease: Human granulocytic anaplasmosis (HGA)



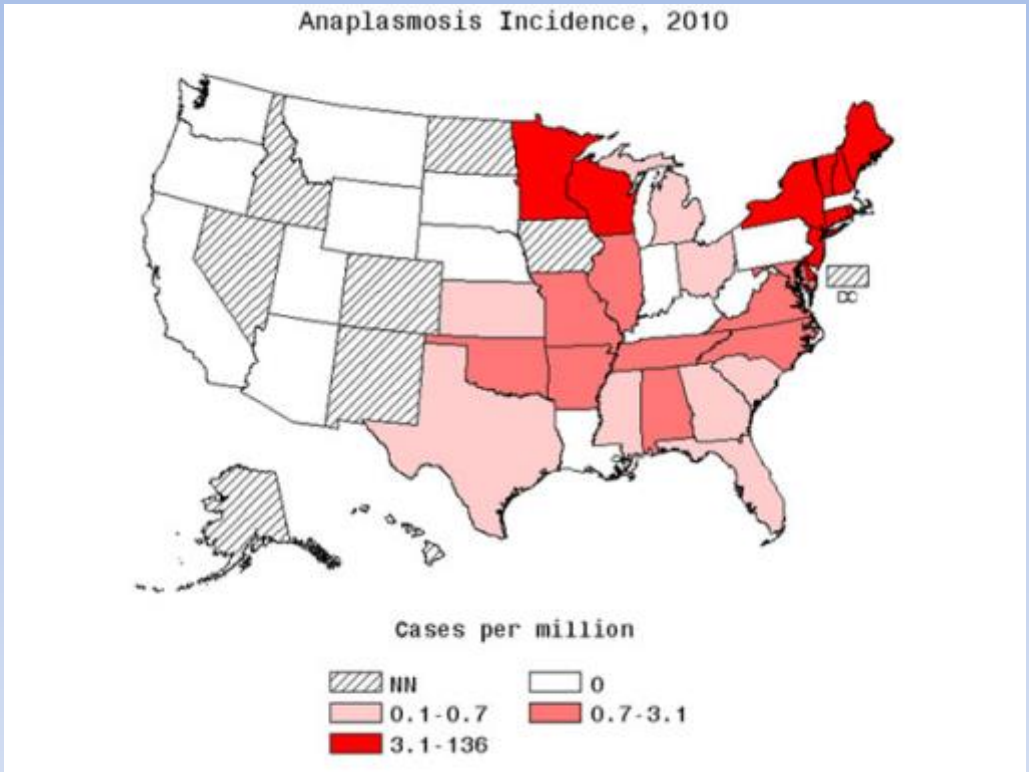
# Anaplasmosis

- Clinical
  - Fever, headache, malaise, myalgia common
  - Respiratory and/or GI symptoms (cough/dyspnea, nausea, diarrhea, vomiting) in some
  - Leukopenia and thrombocytopenia common
  - Rash rarely observed with anaplasmosis
  - Incubation period typically 1 week
  - Fatal outcomes rare, often associated with immune-compromised conditions

Weil et al. Mayo Clin Proc 2012: 87 (3):233-239

# Annual Incidence of Anaplasmosis in the United States

- First recognized as a disease of humans in the U.S. in the mid-1990's
  - Become reportable in 1999
- The number of anaplasmosis cases reported has increased steadily
  - 348 cases in 2000, to 1,761 cases in 2010
- The incidence of anaplasmosis has also increased
  - 1.4 cases/million persons in 2000 to 6.1 cases/million persons 2010
- The case fatality rate has remained low (less than 1%)

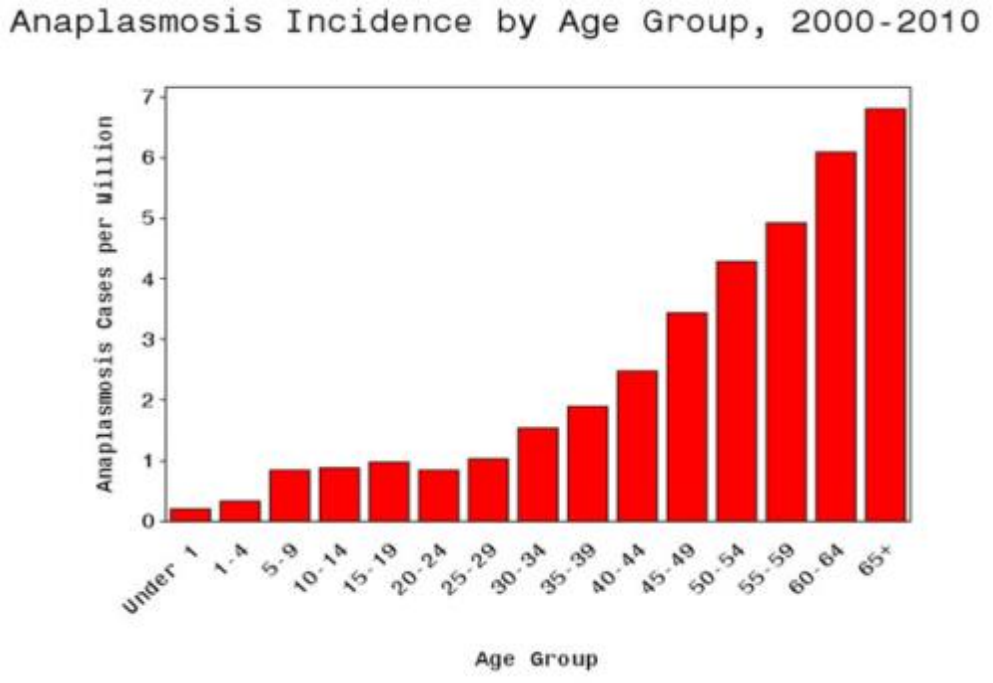



*NN= Not Notifiable

http://www.cdc.gov/anaplasmosis/stats/

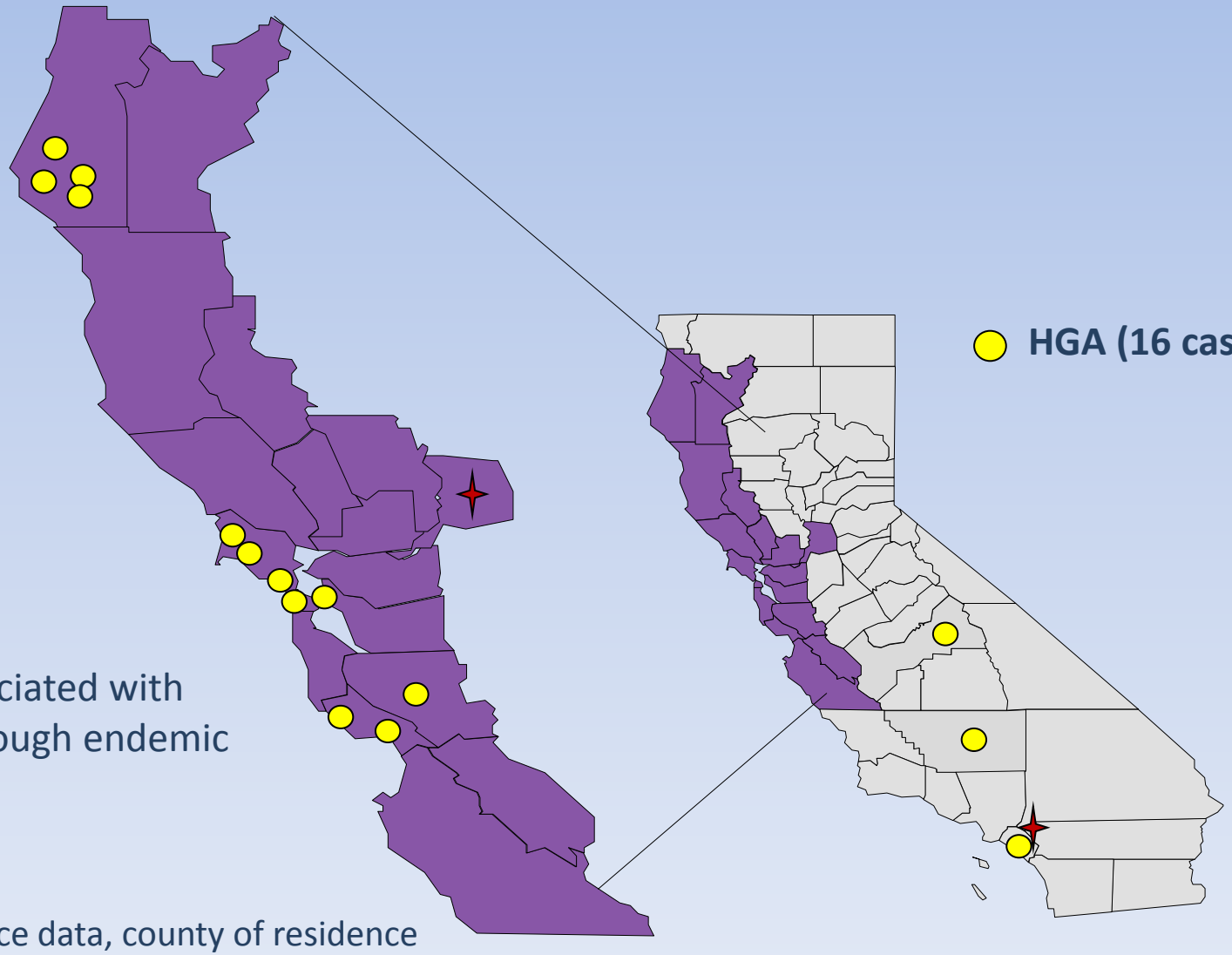
# Incidence by Age Group for Anaplasmosis and Ehrlichiosis in the United States 2000-2010

- The frequency of reported cases of anaplasmosis is highest among males and people over 50 years of age
  - A compromised immune system may increase the risk of severe outcome
- Individuals who reside near or spend time in known tick habitats may be at increased risk for infection




http://www.cdc.gov/anaplasmosis/stats/

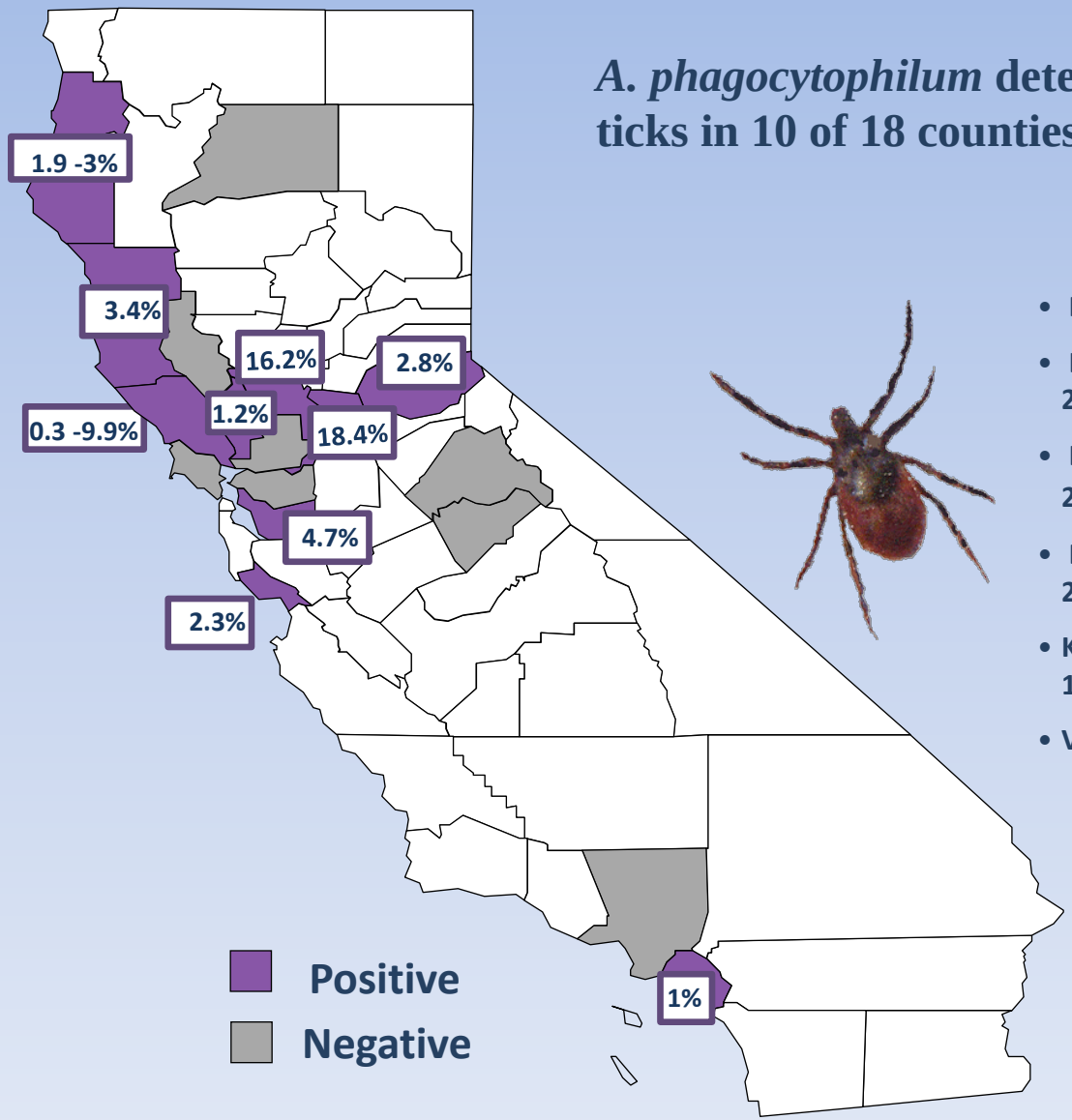
# California Human Cases of Anaplasmosis 1994-2012*




Case associated with travel through endemic area

* CDPH surveillance data, county of residence

# Historic: *A. phagocytophilum* in *Ixodes pacificus*, California 1995-2005

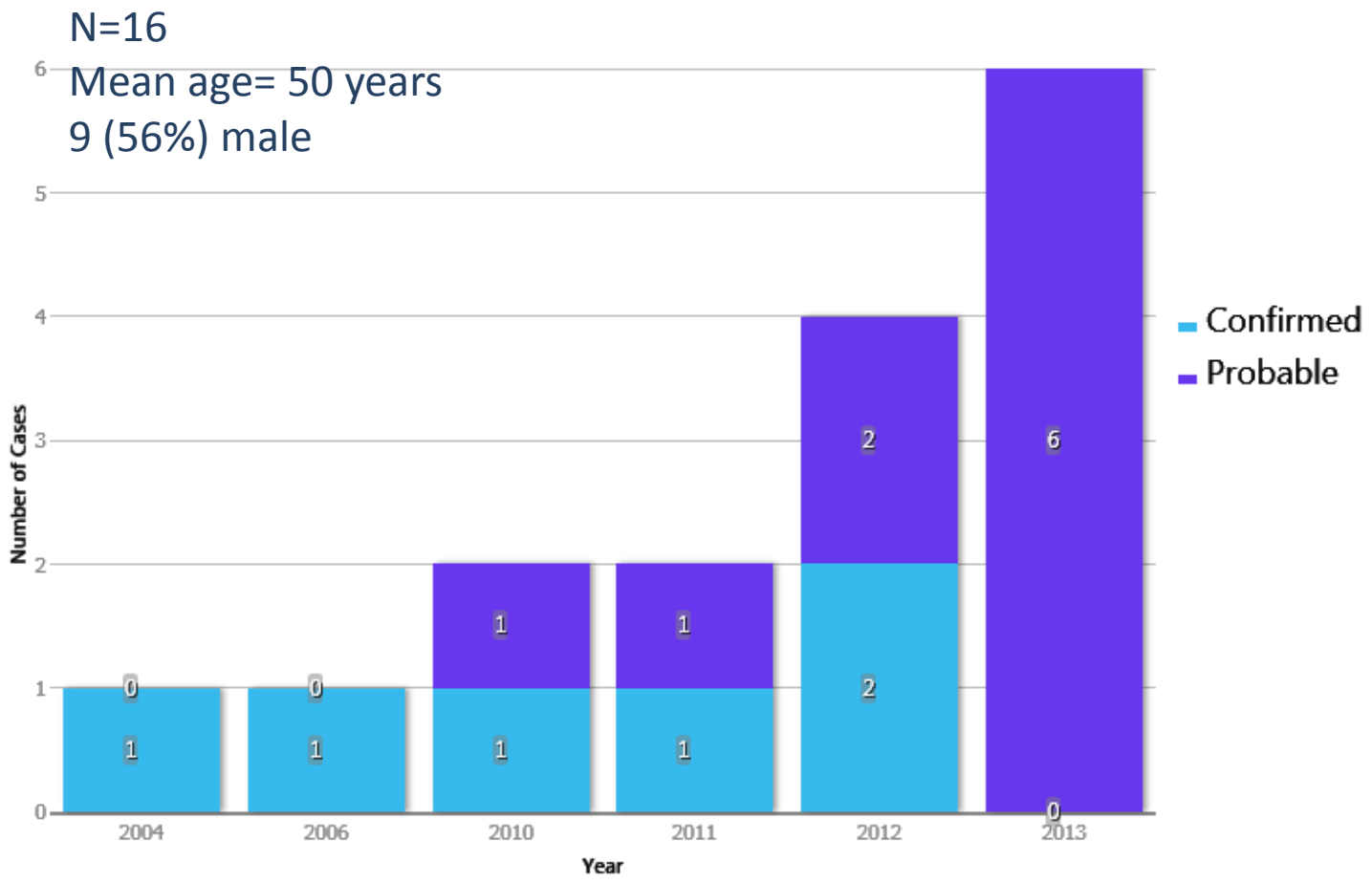



***A. phagocytophilum* detected in adult *I. pacificus* ticks in 10 of 18 counties surveyed (0.3 - 9.9%)**



- Fritz et al, J Vector Ecol. 2005; 30:4-10
- Lane et al, Vector Borne Zoo Dis. 2001;197-210
- Lane et al, J Med Entomol. 2004;41:239-48
- Barlough et al, J. Clin Micro. 35: 2018-2021
- Kramer et al, Am J Trop Med Hyg. 1999; 60: 62-65
- VBDS-CDPH data

# Reported Anaplasmosis cases, California, 2004-2013



## Mammalian Reservoir *Anaplasma phagocytophilum*

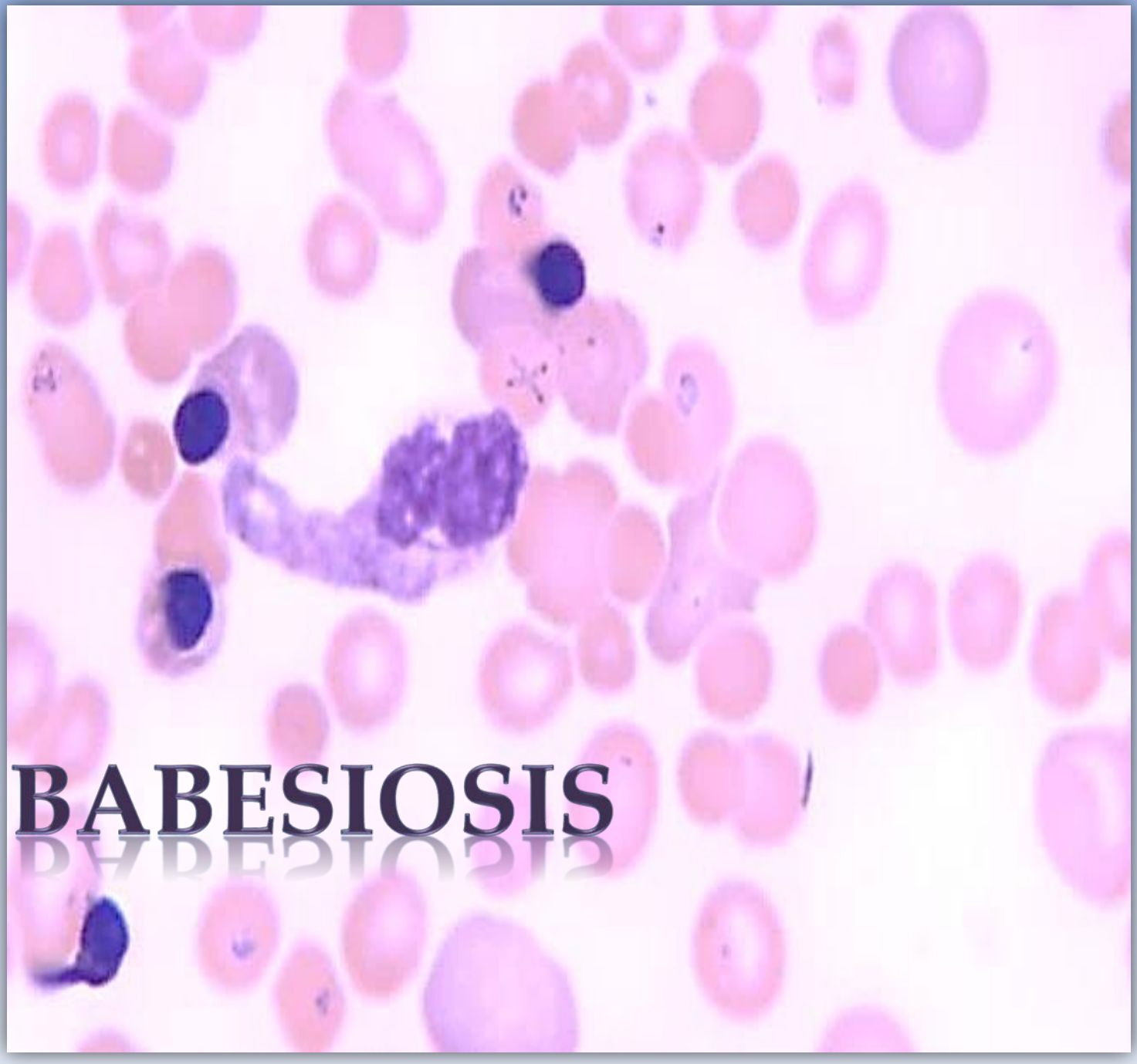
- Nicholson et al. 1999
  - Rodent study in Sonoma, Placer, Santa Cruz counties
  - Dusky-footed woodrats (*Neotoma fuscipes*)
    - 34% seroreactive
    - Anaplasma DNA detected in 31% of seroreactive woodrats

To learn more about anaplasmosis in California, visit the CDPH website at:

http://www.cdph.ca.gov/healthinfo/discond/Pages/Anaplasmosis.aspx

Click to go table of contents

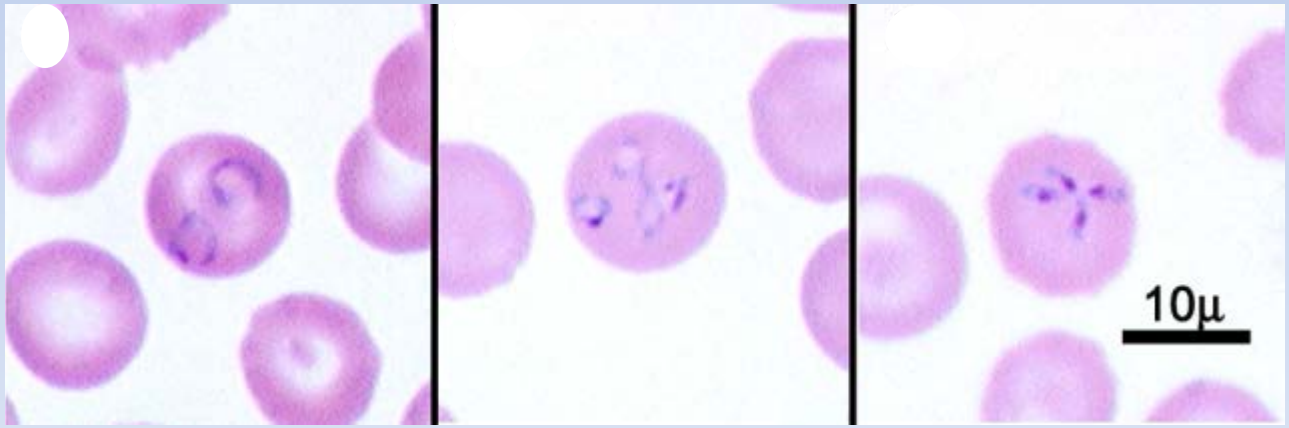
# BABESIOSIS



Vector Borne Disease Section
VBDS
California Department of Public Health

# Babesiosis

- Intraerythrocytic protozoan (piroplasm)
  - *Babesia divergens* (primarily Europe)
  - *Babesia microti* (Northeastern and North Central U.S.)
  - *Babesia duncani* (Western U.S.)
- *B. duncani* (WA-1 type *Babesia)*
  - Most recently characterized human *Babesia* sp.*




Common morphology of small *Babesia* . Left to right: ring form, amoeboid, "Maltese-cross" or dividing form. Giemsa-stained blood smear of *B. duncani.*

* (Conrad et al, 2006 Int J. Parasitol., (36): 779-789)

# Clinical Human Babesiosis

## Signs and symptoms

- Infections can be asymptomatic
- Gradual onset of high fever, chills, fatigue, malaise, and anorexia
- Less frequent: arthralgia, myalgia, nausea and vomiting, abdominal pain
- Leukopenia, thrombocytopenia are common
- *B. duncani* infection may cause pulmonary congestion
- Severe hemolytic anemia reported
- Rash is rare

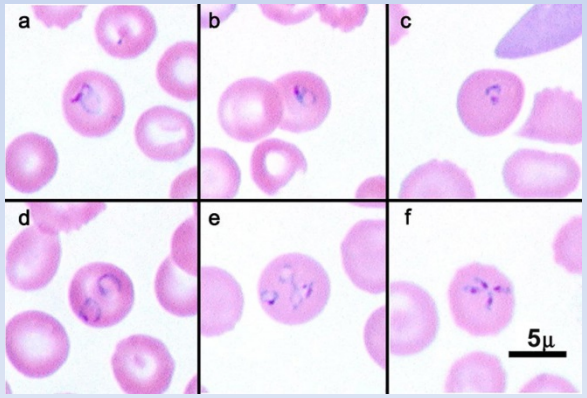
## Predisposing factors for acute clinical disease

- Older age --majority of cases >50 years old
- Immunosuppression / splenectomy

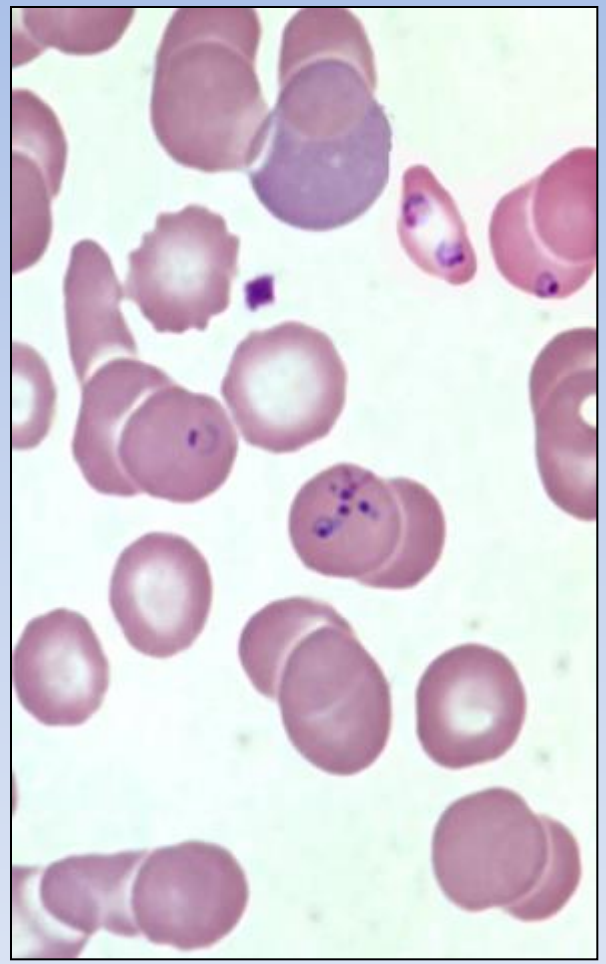
* Kjemtrup and Conrad 2001. Emerging Infections ASM Press pp. 175-195

# Diagnosis of Babesiosis

- Clinical symptoms
- Parasites on Geimsa-stained thin blood smears
- Serology: Immunoflorescent antibody test (IFAT) available now in commercial laboratories; immunoblot
- Hamster inoculation (CDC, research)
- PCR (CDC, research)



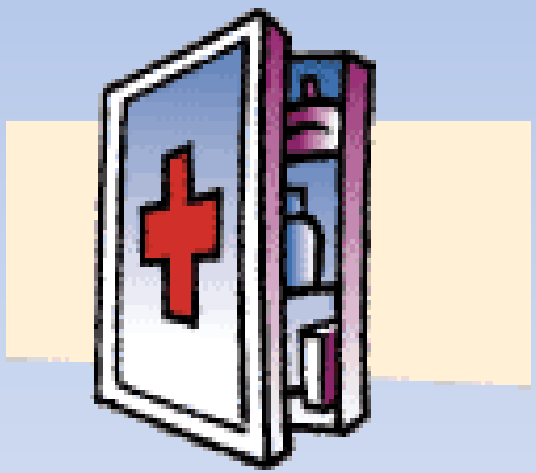
# Blood Smear Evaluation: *Babesia*



*Babesia:* Ring form may be confused with Plasmodium but dividing tetrads typical of *Babesia* spp.

# Treatment of Babesiosis

- Azithromycin and Atovaquone
- Quinine and Clindamycin
- Blood transfusion

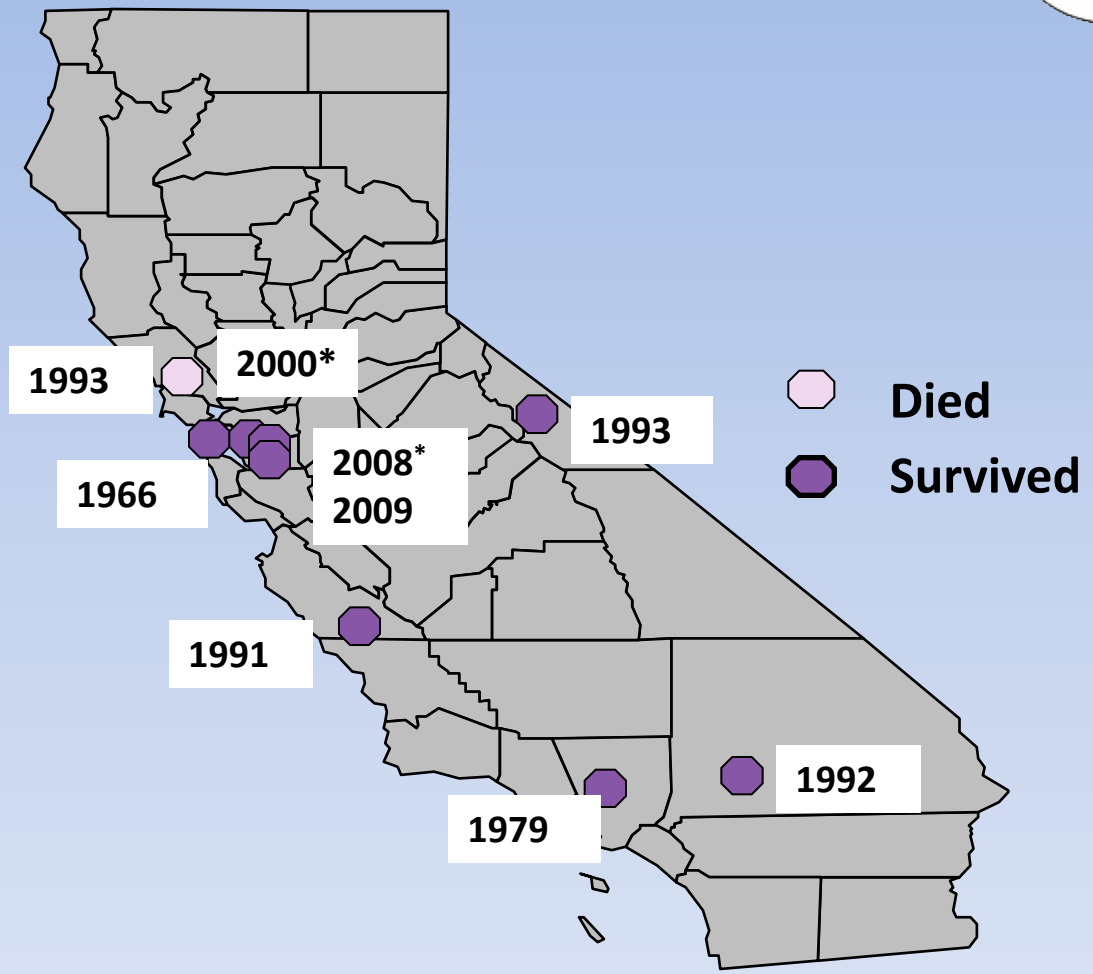


Vannier E, Krause PJ. Human babesiosis. N Engl J Med. 2012 Jun 21;366(25):2397-407

# *Babesia duncani* cases in California, 1966-present*

11 cases of babesiosis caused by *Babesia duncani* or closely related species have been documented in California, 1966 - present.

*Blood donor and recipient

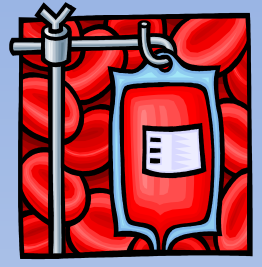


# Babesiosis Ecology in California

Animal reservoirs and tick vectors are unknown

Genetically identical *Babesia* to California human *Babesia* spp. have been recovered from bighorn sheep and deer in California, some in areas where human cases have been exposed. Tick vector is unknown.

Kjemtrup et al, Parasitology 2000: 487-493



# Human Babesiosis: Blood Transfusion Risk

- Transfusion transmitted babesiosis (mostly *Babesia microti*) is the leading infectious cause of mortality (38%) in transfusion recipients as reported to the Food and Drug Administration.
- Infected donors have been identified year around; infected recipients have been identified in non-endemic states

Prevention:

- Prescreen on donation questionnaire
- Monitor recipient for febrile illness post transfusion, particularly in endemic areas
- Blood bank screening
  - Test for *B. microti* under development
- Documented infection results in permanent deferral

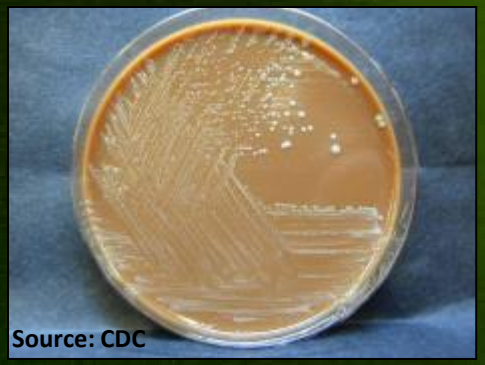
http://www.aabb.org/programs/publications/bulletins/Documents/ab14-05.pdf

To learn more about babesiosis in California, visit the CDPH website at:

http://www.cdph.ca.gov/healthinfo/discond/Pages/Babesiosis.aspx

Click to go table of contents

# Tularemia

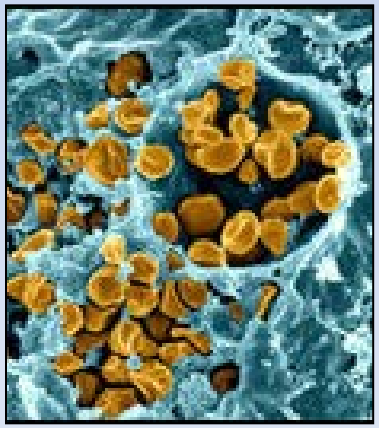



Source: CDC

American dog tick *(Dermacentor variabilis*)

# Tularemia

- Caused by *Francisella tularensis*
  - Gram negative bacteria
- First described from ground squirrels in Tulare Co., CA in 1912*
- Two primary biovars (type A and B)
  - Type A associated with arthropod vectors (biting flies, ticks) and mammalian hosts (rabbits, rodents, hares, ground squirrels)
    - Tends to cause more virulent infections
  - Type B associated with water
    - Tends to cause less virulent infections**
- Considered a Category A bioterrorism agent



Source: CDC

*McCoy and Chapin. 1912 J. Infect Dis; 10:61-72
**Farlow et al., 2001. J. Clin Micro: 3186-3192

# Symptoms of Tularemia

Incubation 1-21 days

Case fatality proportion: 0-14% (higher for type A in eastern US)

## Six classic forms:

1. Ulceroglandular: Ulcers on the skin or mouth, swollen and painful lymph glands, swollen and painful eyes, and a sore throat
   - Most common
   - Tick or fly bites and animal contact usual exposure
2. Glandular: regional lymphadenopathy but no cutaneous lesions
3. Oculoglandular: photopobia, tearing, conjunctivitis, small yellow conjunctival ulcers or papules
   - Associated with exposure to contaminated fingers, splashes and aerosols

Source: CDC

# Symptoms of Tularemia

Six classic forms (continued)*:

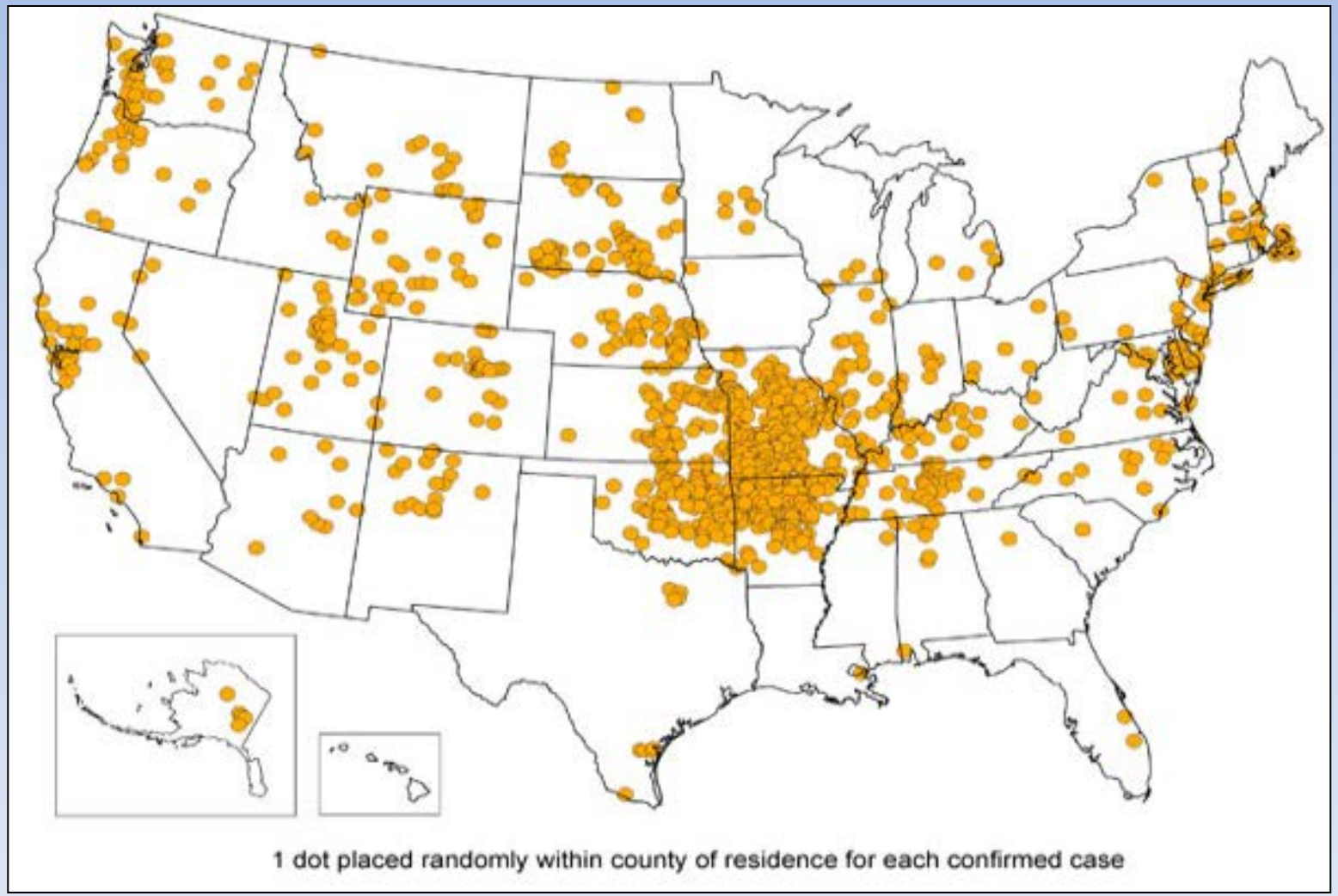
4. Pharyngeal: fever, sore throat, exudative pharyngitis
   - Associated with contaminated food or water

5. Typhoidal: febrile illness, no lymphadenopathy
   - No direct exposure association-exposure to potential tick bites, outdoor exposure, should be sought

6. Pneumonic: fever, chills, cough , pneumonia
   - Often associated with occupational exposure e.g. sheep shearers, farmers, landscapers, lab workers

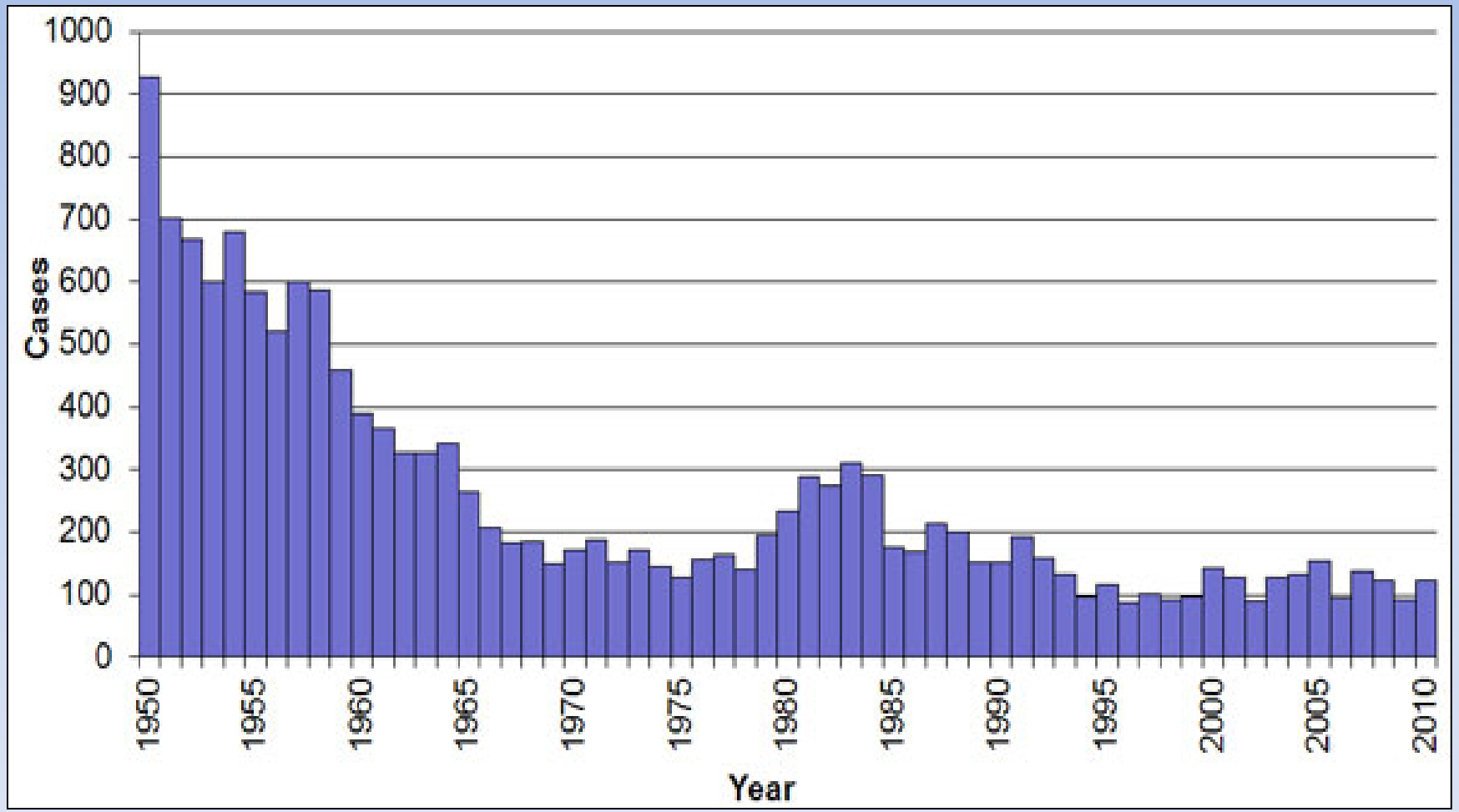
* Mandell et al, Principals and Practices of Infectious Diseases, 2005 pp 2674-2685

# Reported Cases of Tularemia, United States 2001 - 2010



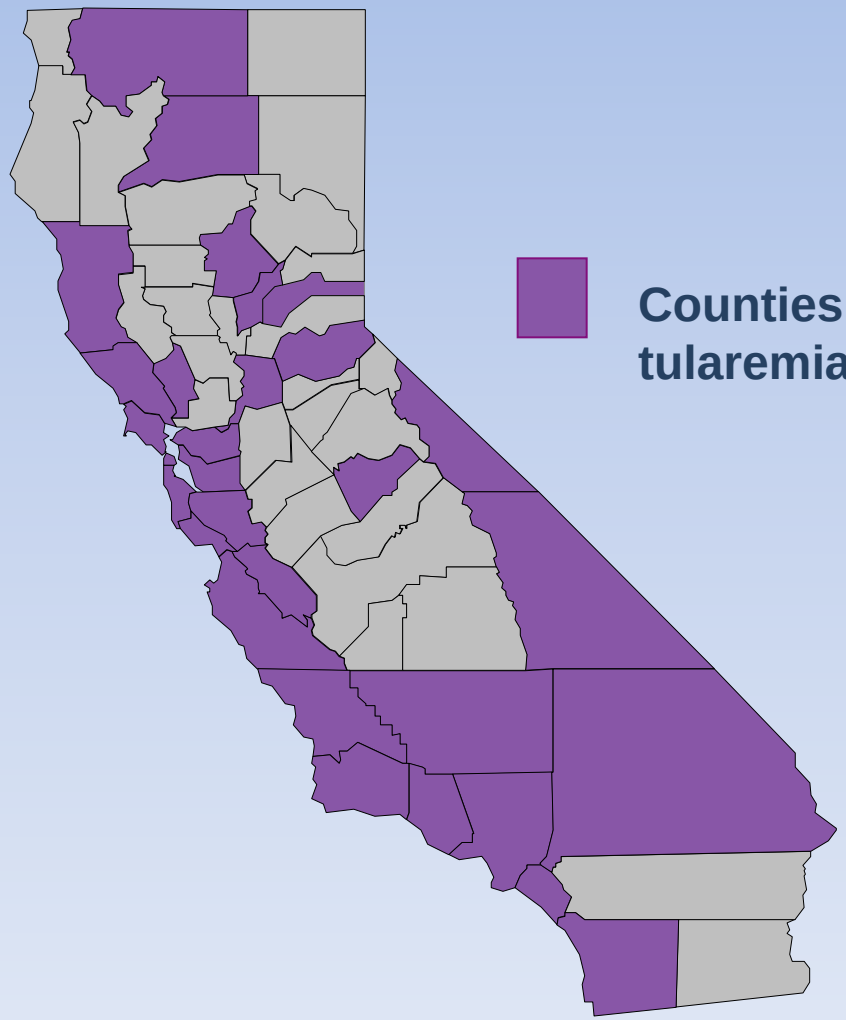

http://www.cdc.gov/tularemia/statistics/map.html

# Reported Tularemia Cases by Year, United States, 1950 - 2010




http://www.cdc.gov/tularemia/statistics/year.html

# Tularemia Surveillance California 1980 - 2013



Counties that reported human tularemia cases

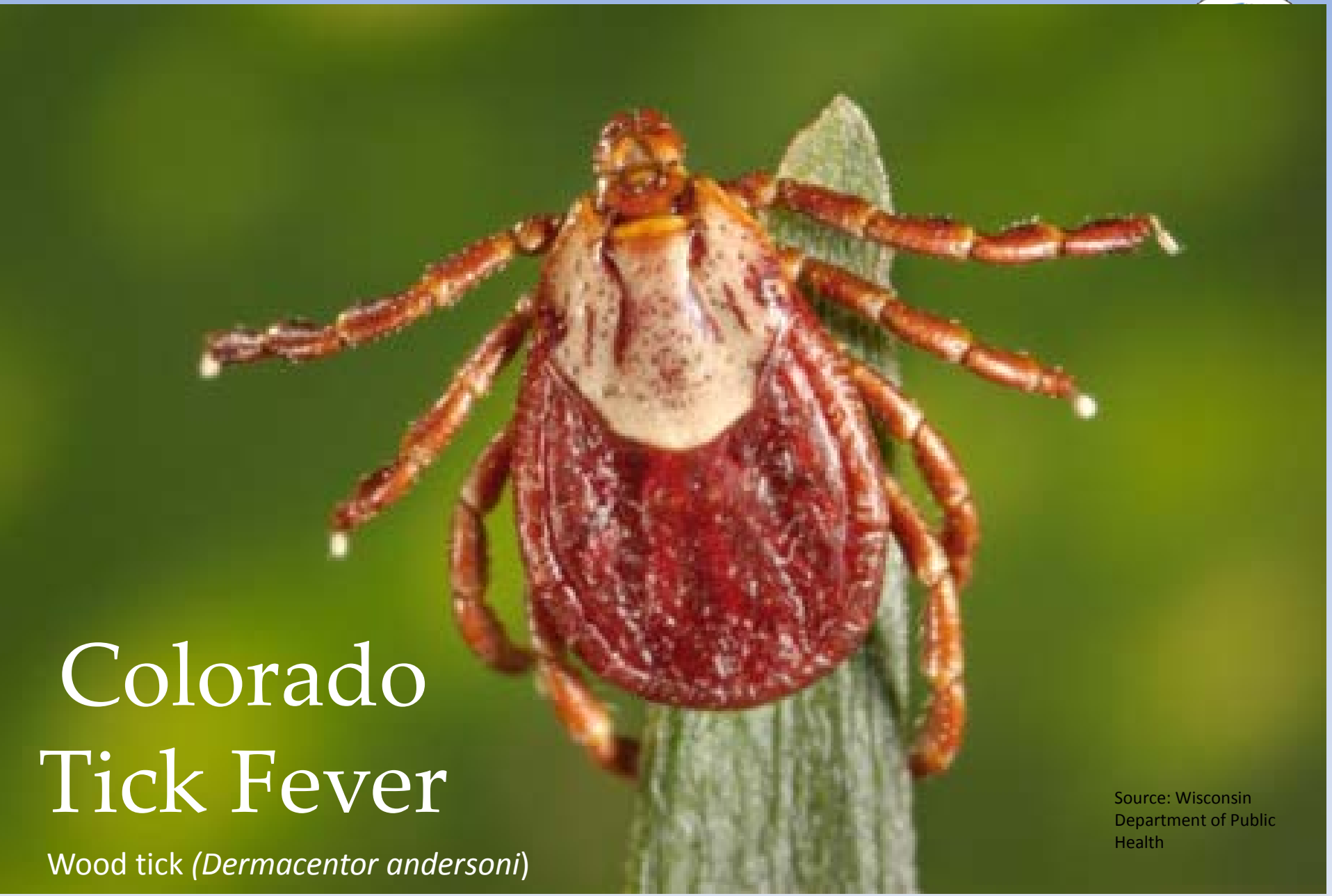
# Transmission

- Biting arthropod (such as tick, deerfly)
- Exposure can also occur through contact with an infected carcass
- Eating / drinking contaminated animals or infected water sources
- Inhalation of bacteria
- NOT spread person-to-person

To find out more about tularemia in California, visit the CDPH website at:

http://www.cdph.ca.gov/healthinfo/discond/Pages/Tularemia.aspx

Click to go table of contents



# Colorado Tick Fever

Wood tick (*Dermacentor andersoni*)

Source: Wisconsin Department of Public Health

# Colorado Tick Fever (CTF)

- Double-stranded RNA virus
- Family: *Reoviridiae*; Genus: *Coltivirus*
- Transmitted primarily by *Dermacentor andersoni*
  - Secondary vector *Dermacentor occidentalis*
- Small rodents are primary reservoirs

# CTF Clinical Features

- Incubation period 2-3 days (range 1-14 days)
- Nonspecific febrile illness
- Fever is often biphasic
- Rarely presents as encephalitis
- ~15% of cases hospitalized
- Illness duration 7-10 days
  - Malaise can persist for weeks

Brackney MM, Marfin AA, Staples JE, Stallones L, Keefe T, Black WC, Campbell GL. Epidemiology of Colorado tick fever in Montana, Utah, and Wyoming, 1995-2003. Vector Borne Zoonotic Dis. 2010 May;10(4):381-5

# CTF Diagnosis

- Testing available at CDC and some state health departments
- Viremia can persist for weeks due to CTF virus infecting red blood cells
- Culture and RT-PCR performed during first two weeks of illness
- IgM and IgG antibodies slow to develop
- Convalescent samples are key to serologic diagnosis
  - If sample is obtained within first two weeks of illness onset, lack of IgM does not rule out the diagnosis

*Staples, J. Erin. Tick-borne Viral Diseases: Colorado Tick Fever, Powassan. Division of Vector-borne Infectious Disease, CDC

# CTF Treatment and Outcome

- No specific treatment
- Majority of cases with self-limited illness
- Complications and fatalities are rare
  - Rare neurologic illness; encephalitis and meningitis more common in children*

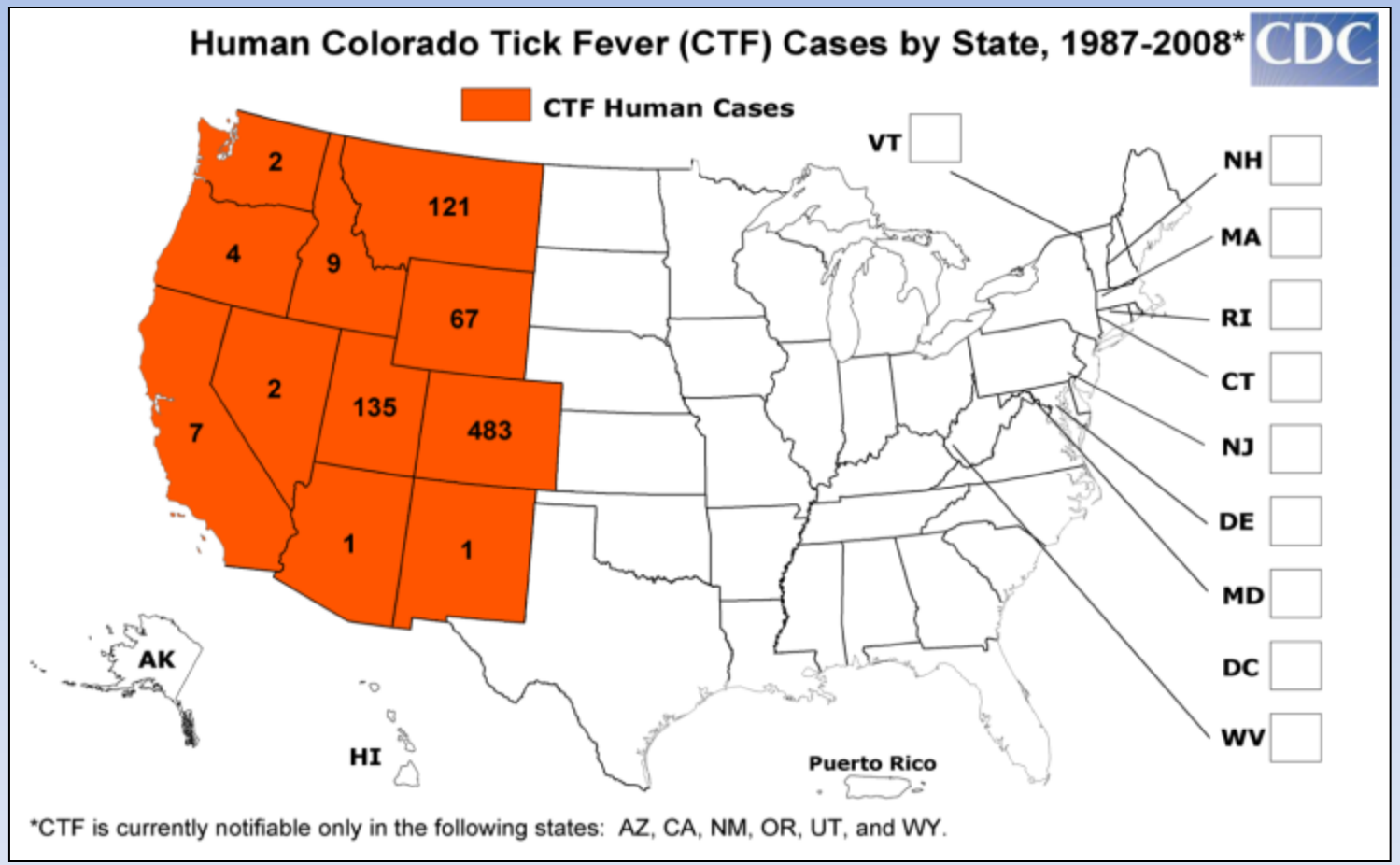
*Romer et al, Inf. Ds. Clin. N. Am. 2008

# CTF Epidemiology

- Endemic to mountainous regions (4,000-10,000 feet) of western U.S. and southwestern Canada
- CTF is currently reportable in only 5 states*
  - AZ, NM, OR, UT, WY
- 90% of CTF cases usually recall tick bite
- Other modes of transmission
  - Blood-borne
  - Laboratory transmission

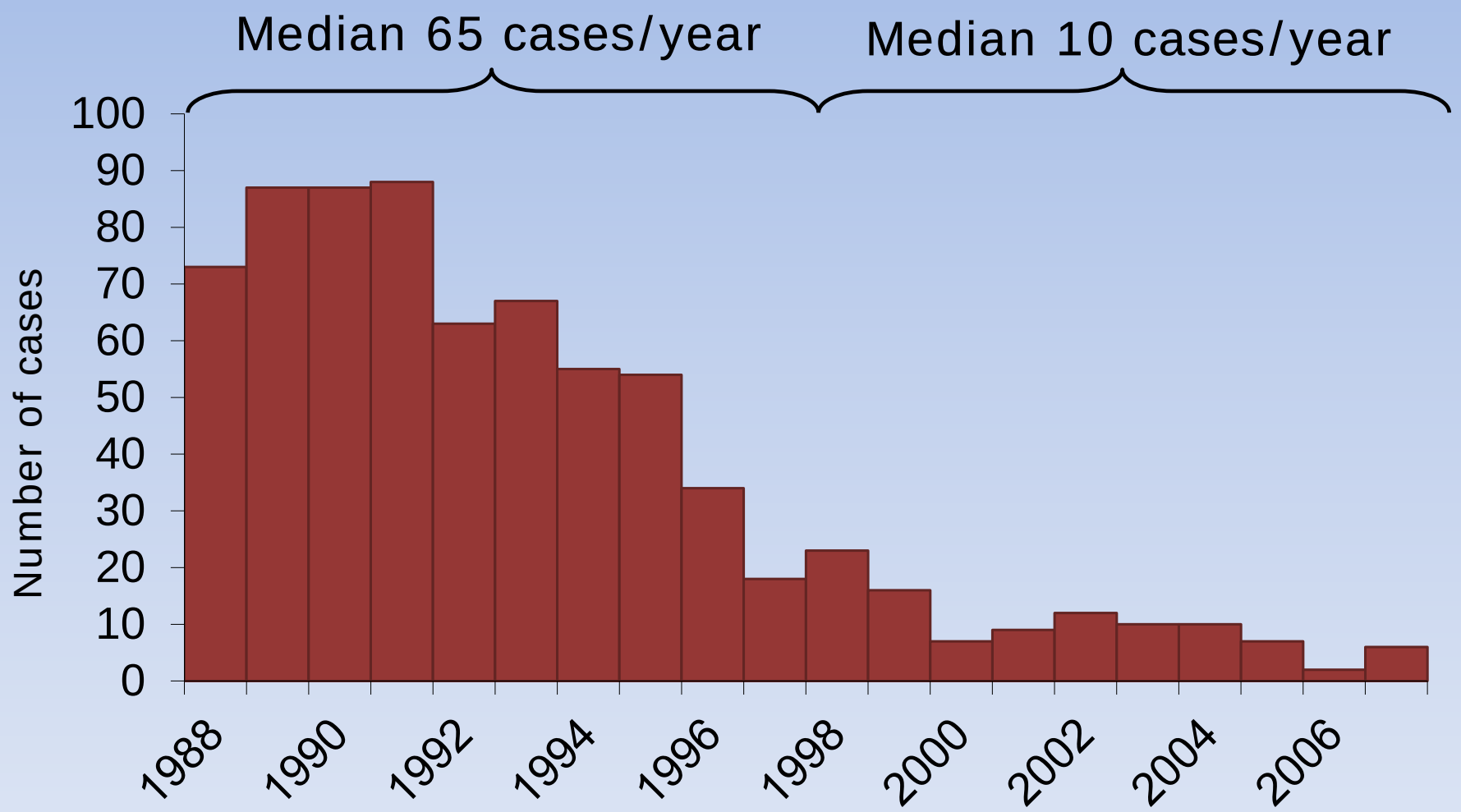
*Staples, J. Erin. Tick-borne Viral Diseases: Colorado Tick Fever, Powassan. Division of Vector-borne Infectious Disease, CDC

# Distribution of Human CTF Cases in the United States 1987 - 2008



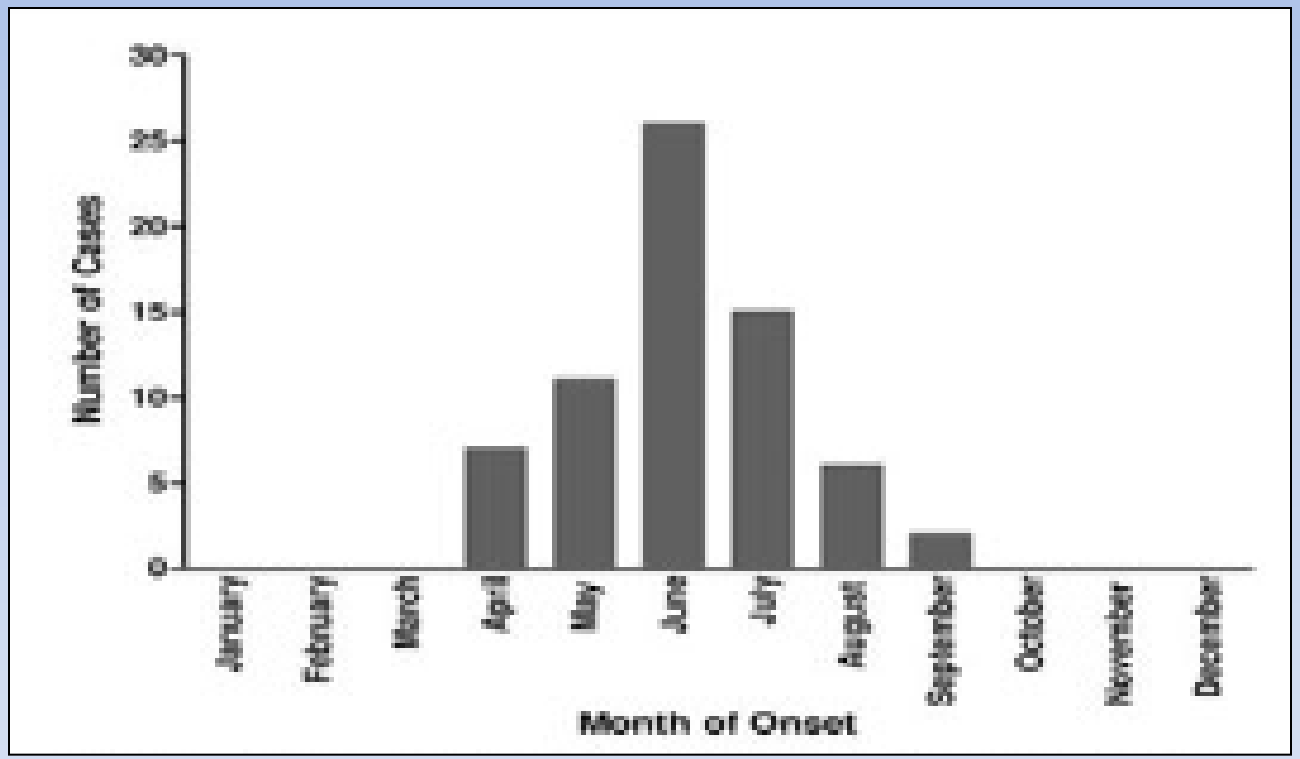

Staples, J. Erin. Tick-borne Viral Diseases: Colorado Tick Fever, Powassan. Division of Vector-borne Infectious Disease, CDC

# CTF Cases by Year in the United States 1988 - 2007




*Staples, J. Erin. Tick-borne Viral Diseases: Colorado Tick Fever, Powassan. Division of Vector-borne Infectious Disease, CDC

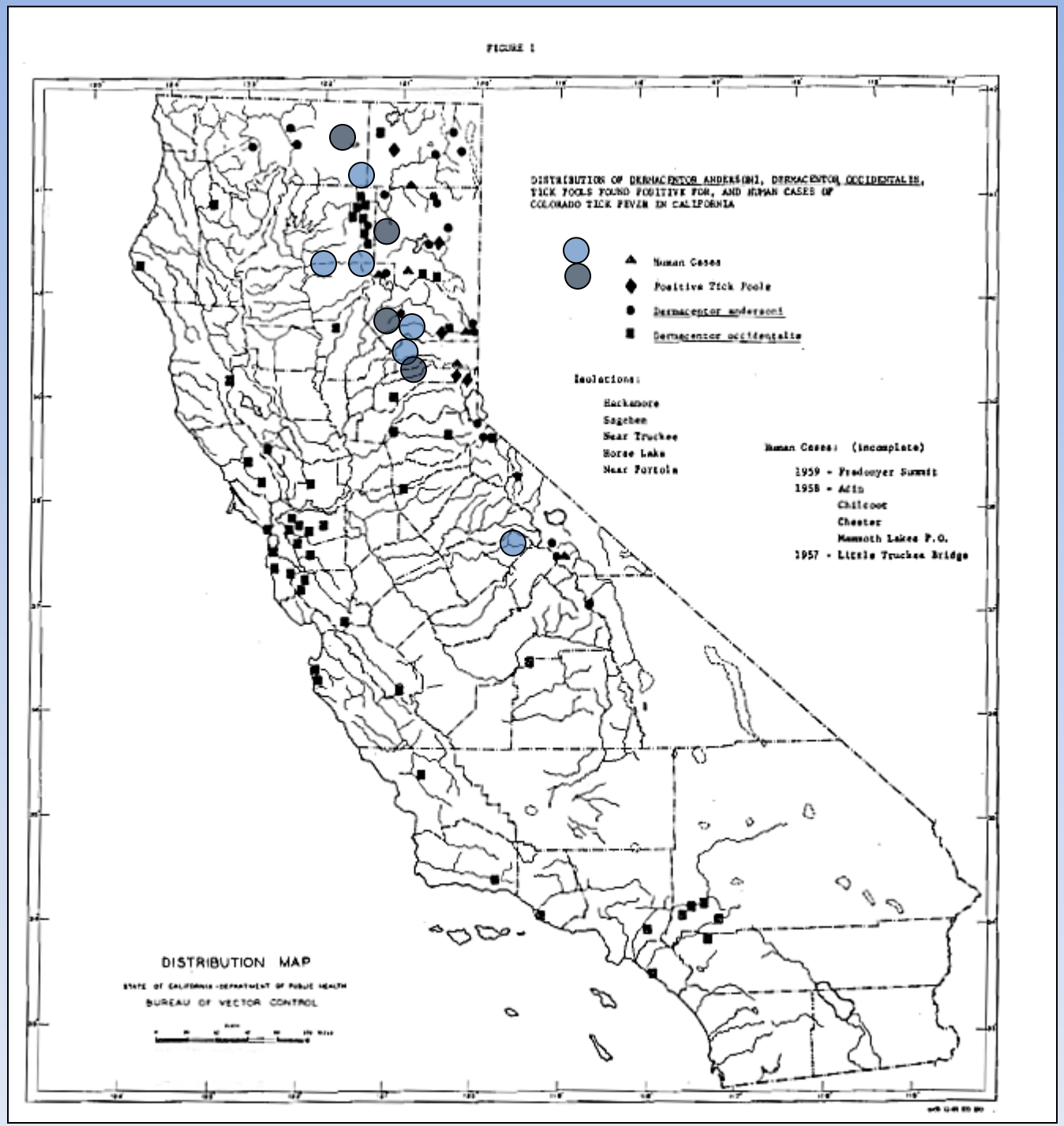
# Month of Illness Onset for CTF Cases MT, UT, and WY, 1995 - 2003



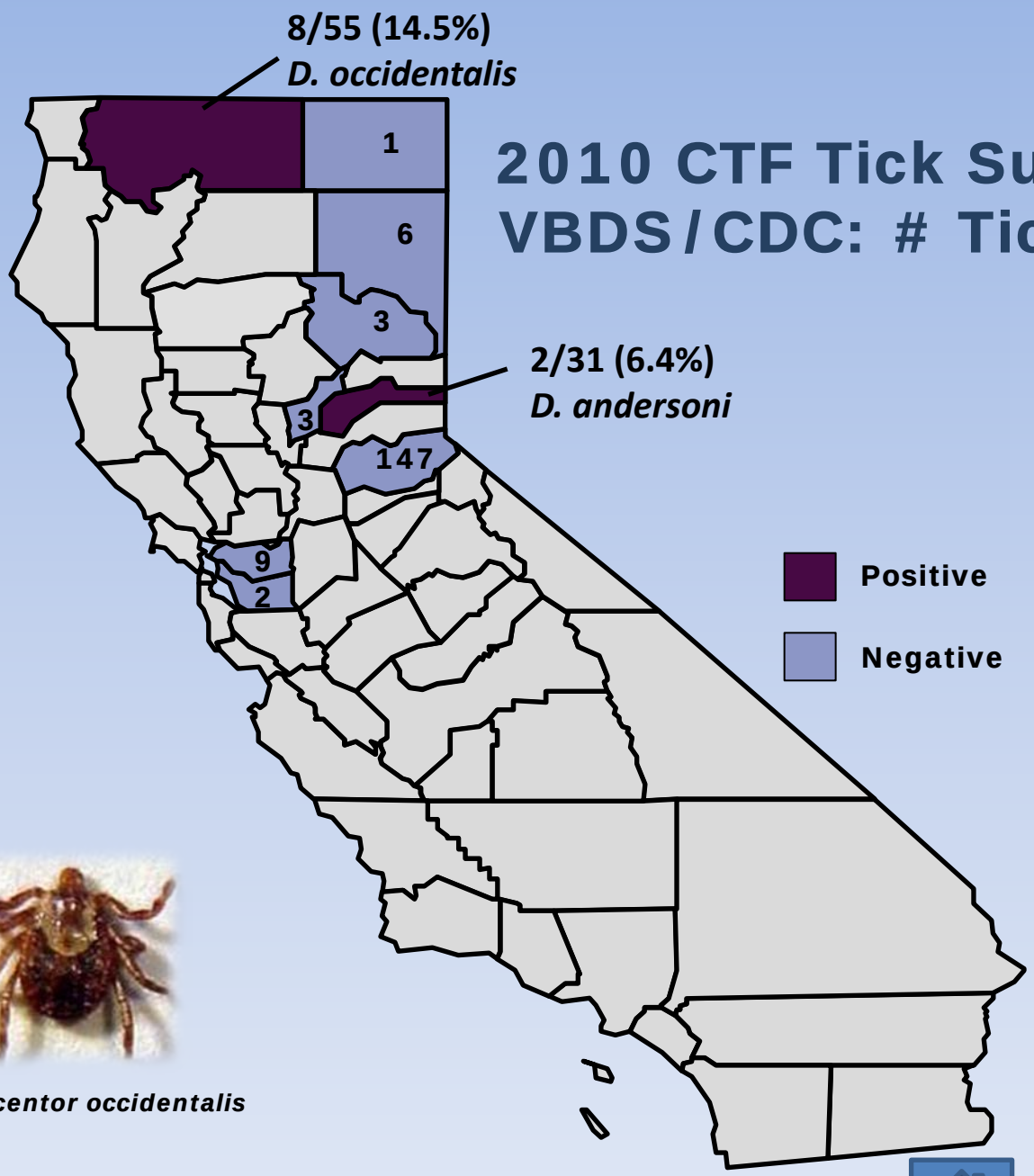

Brackney M, et.al. Vector-Borne and Zoonotic Diseases. May 2010, 10(4): 381-385

# Historic Detection CTF in California 1959

(Murray-Barnes, Bureau Vector Control Report)



# 2010 CTF Tick Surveillance
# VBDS/CDC: # Ticks Tested



Source: CDC

***Dermacentor andersoni***

***Dermacentor occidentalis***

Click to go table of contents

# Tick Paralysis

# Tick Paralysis

- Tick paralysis is a loss of muscle function that results from a neurotoxin transmitted by a biting tick
  - Often associated with *Dermacentor* spp., but other tick species can transmit a neurotoxin
  - More commonly found in children
- Symptoms
  - Unsteady gait, followed several days later by weakness in lower legs
  - Ascending paralysis
  - May cause difficulty breathing and flu-like symptoms
- Treatment
  - Removal of the tick removes the source of the neurotoxin
  - Recovery is rapid once tick is removed
  - Full recovery is expected

Click to go table of contents

Diaz JH. Tick paralysis in the United States. J La State Med Soc. 2010 Sep-Oct;162(5):273-80

# Prevention of Tick-Borne Diseases

# Tick Repellents

www.tickencounter.org

- Treat clothing with permethrin to kill ticks (do not apply to skin)
  - Properly treated clothes can be washed multiple times without retreatment

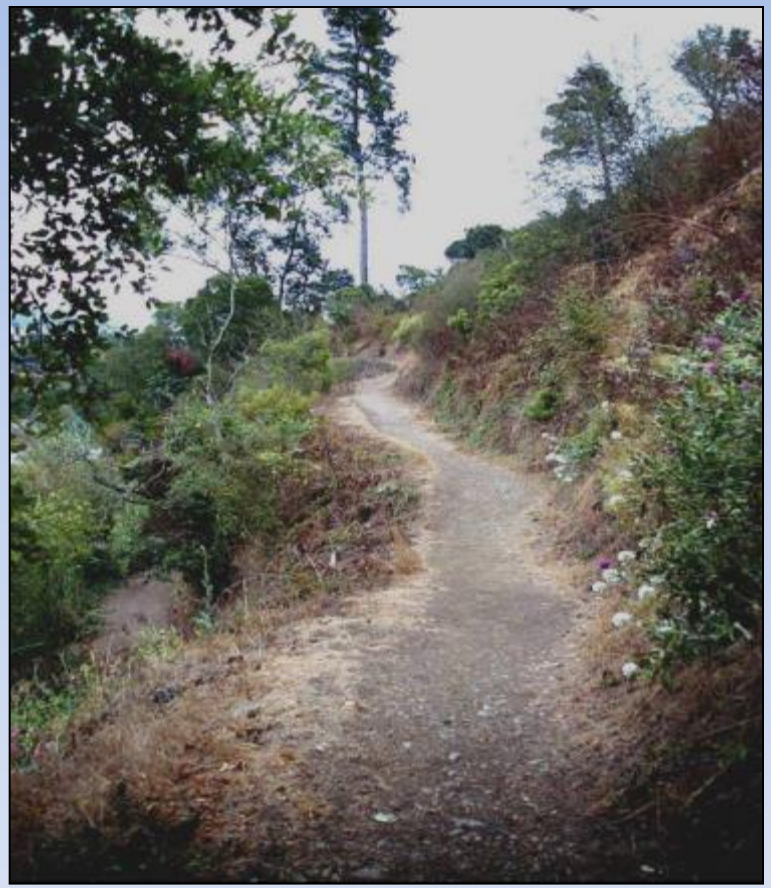
- Apply DEET repellent (>20%) to skin that is not covered by clothing to repel ticks (can be used on clothing too)

Deetonline.org

# Personal Protection: Avoid Areas Where Ticks are Found

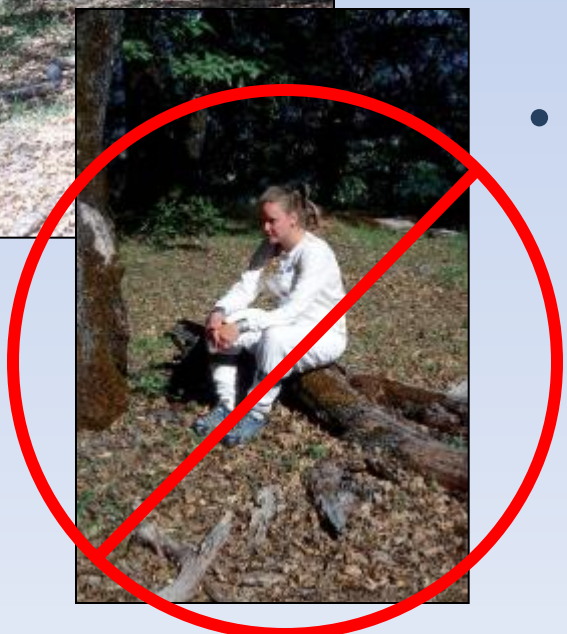
Adult ticks

- Commonly found on grasses and bushes on uphill side of trails
- Stay on trails!



Source: California Department of Public Health

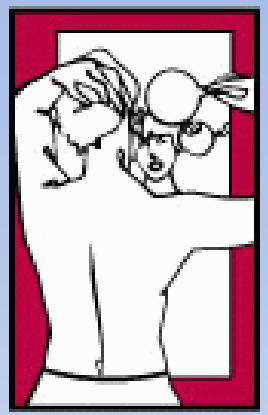
# Personal Protective Measures: Avoid Areas Where Ticks are Found



- Nymphal ticks are found in leaf litter and on trees and logs in hardwood forests
- Avoid contact with logs, tree trunks, and fallen branches in forests

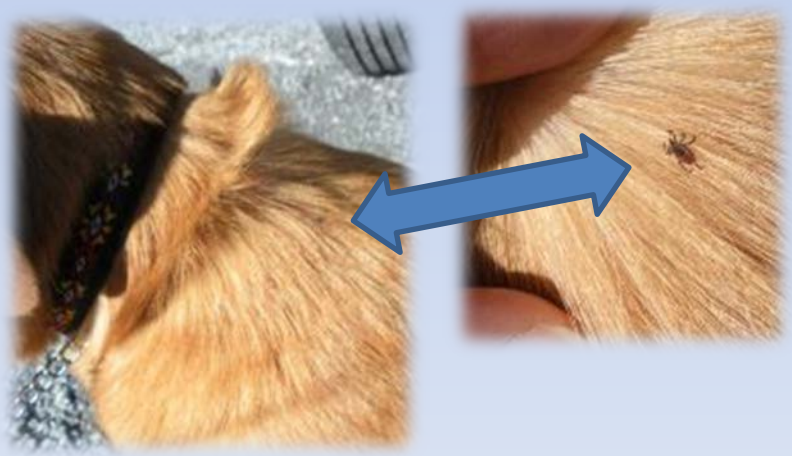
Picture source: Dr. Robert Lane, UC Berkeley

# Personal Protective Measures



Check clothes while in tick habitat. Full body check at home up to three days after being in areas where ticks are found: hair line, armpit, back of knees, groin

Parents should inspect children



Check pets: use effective tick repellents on them

Tick attached at the hairline of a child's head.

Source: used with permission Annie Smith

**I've been bitten by a tick…**

**What do I do now?**

Patient recommendations:

- Promptly remove tick
- Cleanse the area with soap and water
- If you develop any symptoms 1-30 days after bite, consult your physician
- Let your physician know that you were bitten by a tick

Physician recommendations:

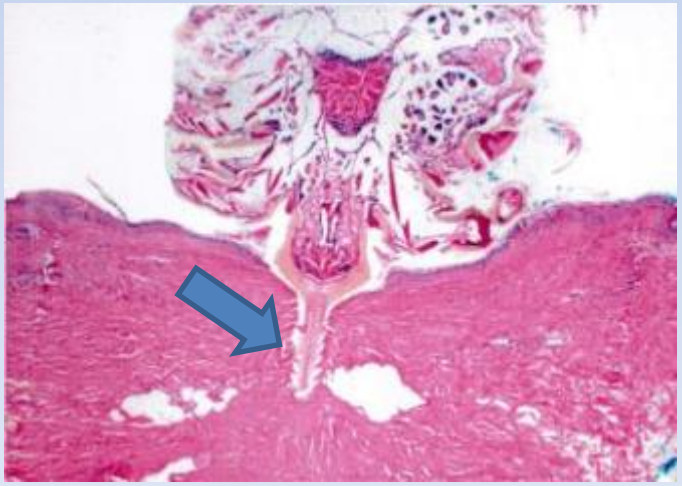
- Prophylactic administration of 200mg doxycycline shown to be useful in highly endemic areas of eastern U.S.; not studied in CA and prevalence does not reach "highly endemic"*
- Testing the tick for medical decision making not recommended by CDPH (http://www.cdph.ca.gov/HealthInfo/discond/Documents/TickTestQandA.pdf)

*Nadleman et al, New England J. of Medicine 2001. 345 (2): 79-84

To prevent disease transmission, remove ticks as soon as they are detected!

# Tick Removal Technique

- Place the tip of fine tweezers around the tick mouthpart
- Pull the tick firmly away from the skin (do not jerk, crush, squeeze, or puncture the tick)
- Do <u>not</u> use insecticides, lighted matches, gasoline, petroleum jelly, or liquid soaps to remove ticks as these techniques may cause injury and are ineffective



Barbs on tick mouth parts can make ticks difficult to remove

Source: Rick Baier, MD, Yosemite Pathology

# Should an attached tick be tested for *Borrelia*?

**NOT** for individual clinical management

- Results not always timely for medical decision making
- Positive result does not mean patient will contract *Borrelia*
  - False positive
  - Tick not attached or not attached long enough to transmit
- Negative result does not guarantee free of exposure to *Borrelia*
  - False negative
  - Could have been bitten by another infected tick that was not detected

STATE OF CALIFORNIA—HEALTH AND HUMAN SERVICES AGENCY

California Department of Public Health
Division of Communicable Disease Control

**Testing ticks for *Borrelia burgdorferi*, the Agent of Lyme Disease**
**Questions and Answers**

http://www.cdph.ca.gov/HealthInfo/discond/Documents/TickTestQandA.pdf

# Tick Testing and Identification

- Submit ticks for identification to local health department, vector control district, or CDPH
  - Ticks can be alive, dead, or preserved in alcohol or formalin
- If tick testing still desired, dead or live western blacklegged ticks can be tested for *Borrelia* by IFA at some commercial laboratories and some local health departments
  - Ticks must be kept moist in small container

Click to go table of contents

# Resources Available from CDPH

# Tick Identification

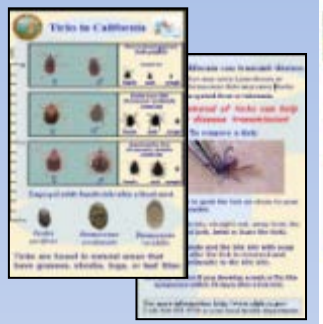
The Vector-Borne Disease Section regularly identifies ticks submitted by public and health care providers

Call (916) 552-9730

for more information

# www.cdph.ca.gov

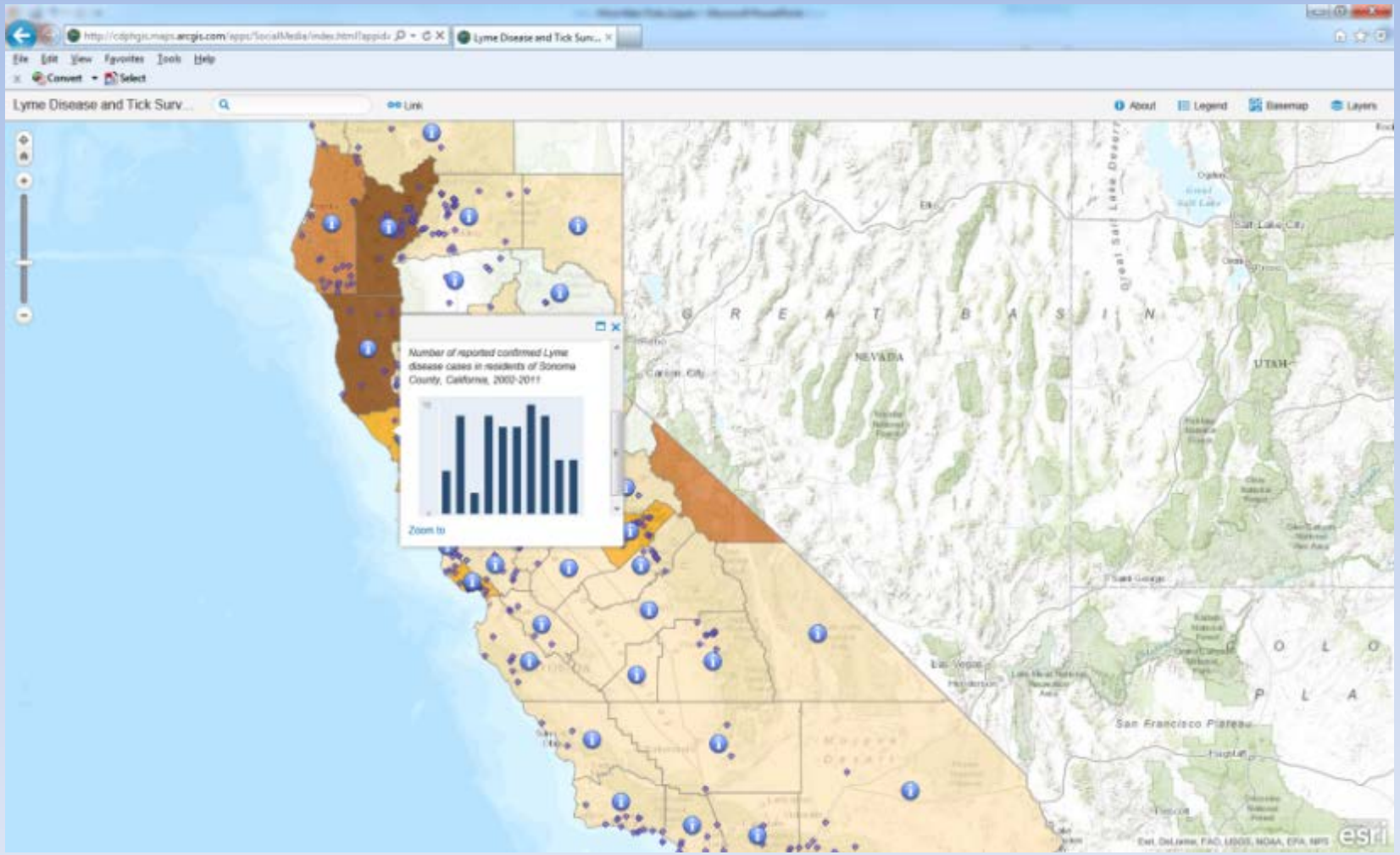
## Type “tick” in search box



Spray,Tuck, Zip! 2011 Contest Winner

# Find Out Where Infected Ticks and Human Cases Occur:

[Interactive Lyme Disease and Western Blacklegged Tick Map]



# Thank you for your attention. A short quiz follows.

Click to go table of contents

# Quiz

1. When considering a diagnosis of tick-borne disease, an important question(s) to include during a patient interview is…(circle all that apply)
   a) Recent history of crawling or attached tick on person
   b) Recent history of crawling or attached tick on pet
   c) Recent history of outdoor activity (e.g., camping, hiking, dog walking, wood gathering)
   d) Recent foreign or domestic travel to a tick-borne disease endemic region
   e) All of the above

# Quiz

2. Which of the following are considered appropriate for tick removal? (circle all that apply)
   a) Fingernail polish
   b) Lit matches
   c) Fine-tipped forceps
   d) Petroleum jelly
   e) All of the above

# Quiz

3. Treatment of Rocky Mountain spotted fever using a tetracycline should be initiated only after laboratory confirmation of infection is obtained.
   a) True
   b) False

# Quiz

4. In California, the following tick(s) transmits *Borrelia burgdorferi*, the agent of Lyme disease (circle all that apply):
   a) Pacific Coast tick (*Dermacentor occidentalis* )
   b) Deer tick or blacklegged tick (*Ixodes scapularis* )
   c) Western blacklegged tick (*Ixodes pacificus* )
   d) Brown dog tick (*Rhipicephalus sanguineus* )

# Quiz

5. What activity would put a patient at risk for tick-borne relapsing fever (circle all that apply)?
   a) Hiking through vegetation
   b) Sleeping in rustic mountain cabin
   c) Petting dogs
   d) Eating / drinking contaminated food or water

# Quiz

6. Which of the following agents is not transmitted by ticks in California?
   a) *Francisella tularensis*
   b) *West Nile virus*
   c) *Babesia duncani*
   d) *Borrelia burgdorferi*
   e) *Anaplasma phagocytophilum*

# Quiz

7. Personal protective measures against tick-borne disease include (circle all that apply):
   a) Apply DEET to skin not covered by clothing
   b) When in tick habitat, check yourself for ticks frequently
   c) Shower when returning from tick-habitat
   d) Conduct full body check for ticks for 3 days after being in areas ticks are found
   e) All of the above

# Quiz Key

- Question 1, E All of the above
- Question 2, C Fine-tipped forceps
- Question 3, B False
- Question 4, C *Ixodes pacificus* (Western blacklegged tick)
- Question 5, B Sleeping in rustic mountain cabin
- Question 6, B West Nile virus
- Question 7, E all of the above

# THE END

California Department of Public Health
Vector-Borne Disease Section
1616 Capitol Avenue
Sacramento, CA 95814
Ph: 916-552-9730
Email: vbds@cdph.ca.gov
Website: www.cdph.ca.gov

Click to go table of contents