

# Ecology of RMSF on Arizona Tribal Lands

## Tribal Vector Borne Disease Meeting



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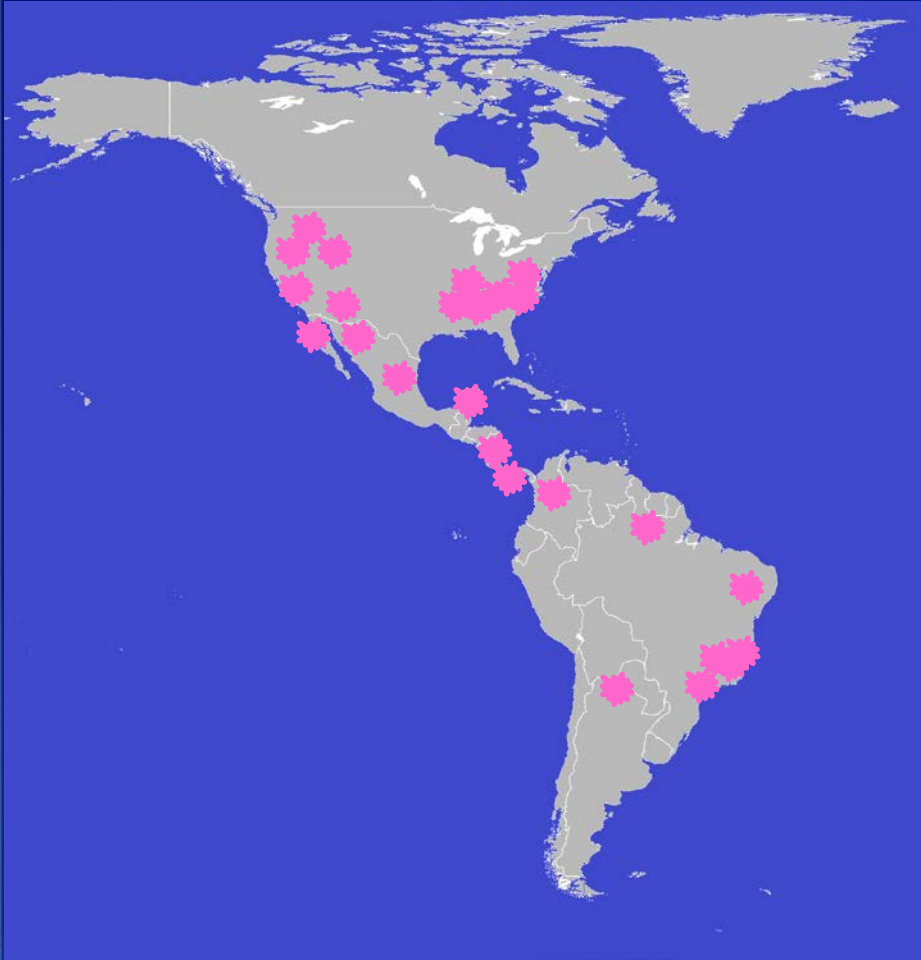
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# Rocky Mountain Spotted Fever – Disease Without Borders

- ❑ Caused by *Rickettsia rickettsii*
- ❑ Infects cells that line the blood vessels throughout the body
- ❑ Results in widespread organ and tissue damage when left untreated or when treatment is delayed
- ❑ 20-80% of cases treated after day 7 of illness are fatal
- ❑ In recovered patients, long-term effects may include impaired hearing, cognitive deficits, gangrene of fingers and toes
- ❑ Transmitted (spread) by ticks



# Rocky Mountain Spotted Fever – Disease Without Borders



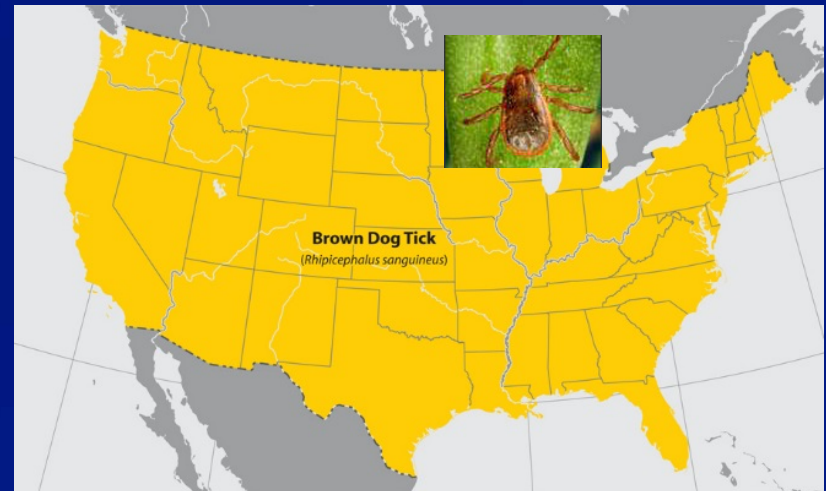
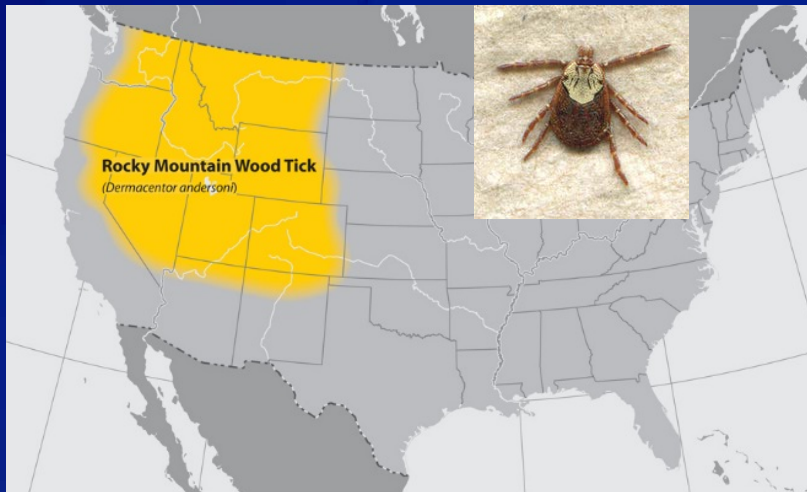
RMSF cases are spread  
throughout North, Central,  
and South America

# Rocky Mountain Spotted Fever – Disease Without Borders



- ❑ *Rickettsia* survives and spreads naturally by being transmitted (passed) between ticks and their hosts.
- ❑ In different regions, RMSF is transmitted by different species of ticks:
  - *Dermacentor*
  - *Rhipicephalus*
  - *Amblyomma*
- ❑ The type of tick-vector can impact the number of RMSF cases, the time of year when cases occur, and even the level of disease severity

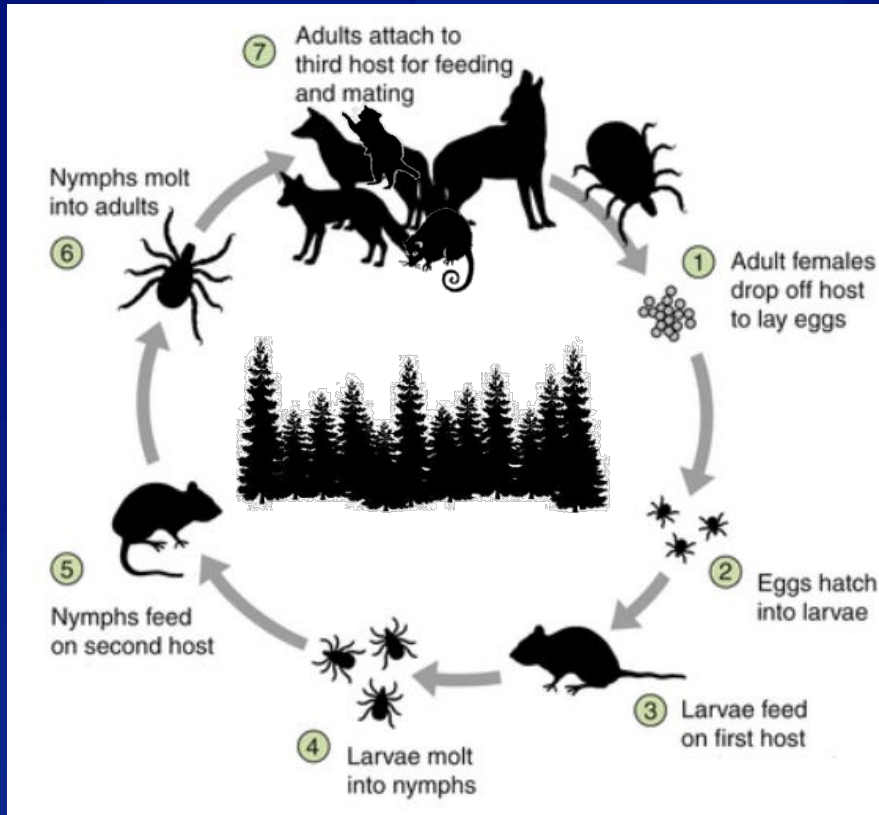
# Ticks transmitting RMSF in Arizona



- ❑ Dermacentor species are believed to be the main RMSF vector in most of the United States
- ❑ Rocky Mountain wood tick is considered the main vector of RMSF in the western US
- ❑ Brown dog tick is present throughout the US



# *Dermacentor* sp. life cycle



- Three active life stages
- Each life stage must feed on blood
- Each life stage feeds only once
- *Dermacentor* spp. live in forested areas and feed mostly on wild animals

# Sylvatic (forest) cycle of *Rickettsia rickettsii*

NATURAL HISTORY OF *R. RICKETTSII* 291

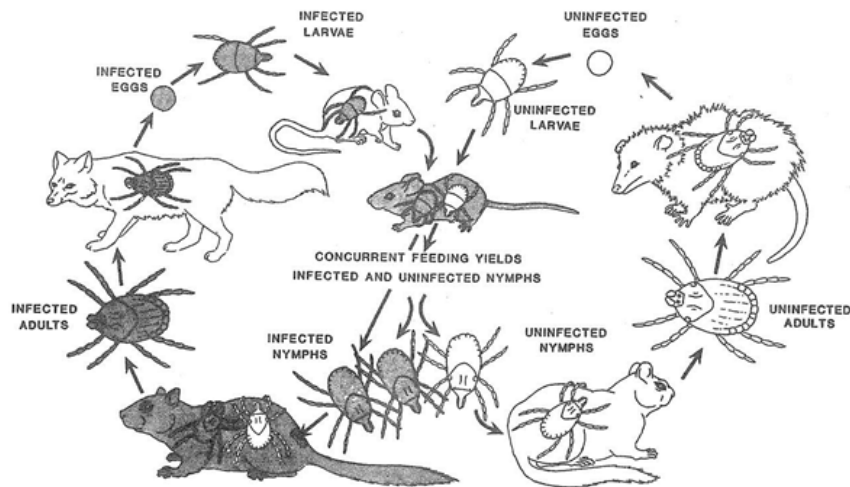


Figure 1 Life cycle of *Rickettsia rickettsii* in its tick and mammalian hosts.

McDade, J. E. and V. F. Newhouse (1986). "Natural history of *Rickettsia rickettsii*." Annual Review of Microbiology 40: 287-309.

- Ticks become infected when feeding on infected animals and pass *Rickettsia* from one life stage to the next;
- They then transmit *Rickettsia* to new hosts during next feeding as nymphs or adults.
- Infected females can pass *Rickettsia* to some of eggs and larvae.

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NATURAL HISTORY OF *R. RICKETTSII* 291

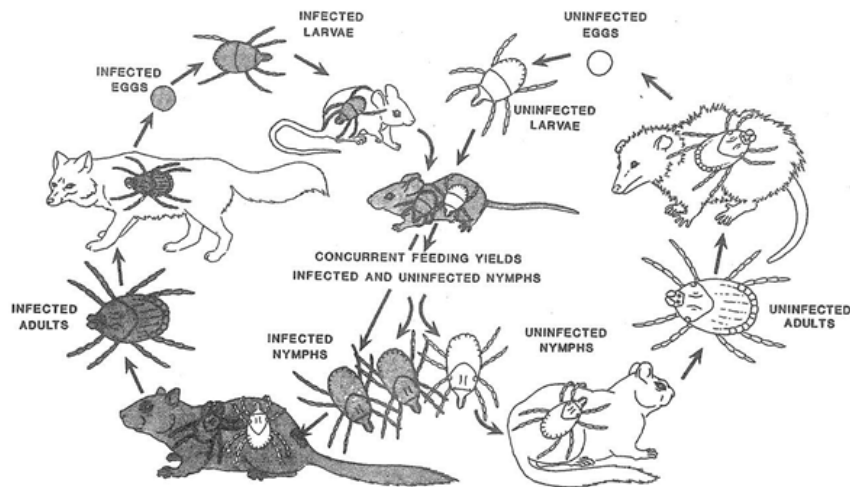


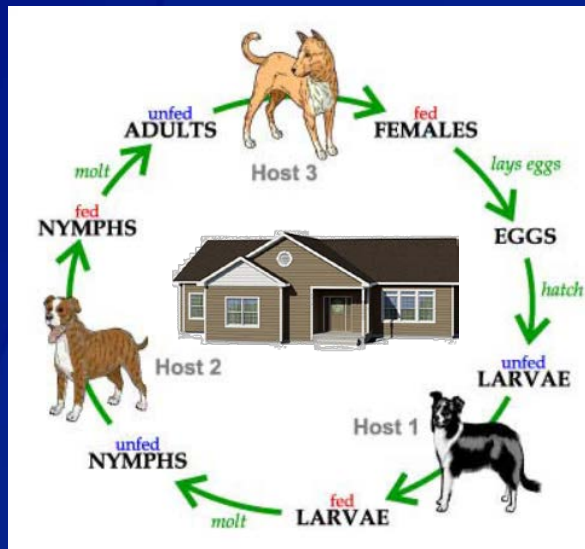
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- ❑ In areas where *Dermacentor* spp. are primary vectors, *Rickettsia* is passed between ticks and wild animals – rodents, rabbits, raccoons, coyotes.
- ❑ Only adult ticks bite humans;
- ❑ Humans become infected when they are bit by infected adult ticks;
- ❑ Infections are rare, sporadic, rarely connected



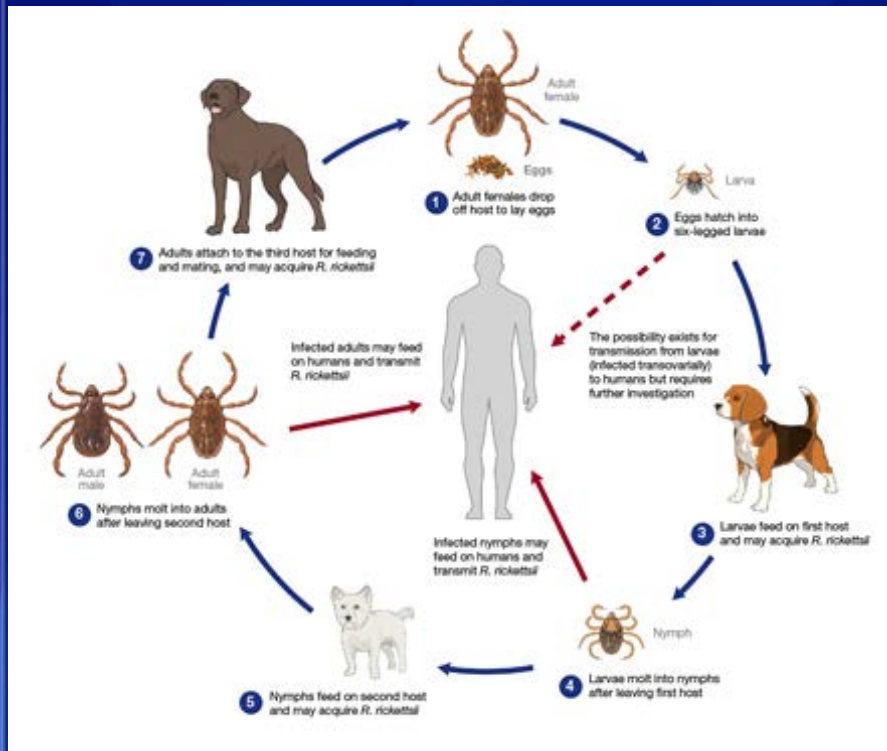
# *Rhipicephalus sanguineus* life cycle



- ☐ 3 active life stages
- ☐ All life stages feed primarily on dogs
- ☐ Dwell in or around human houses
- ☐ Sheltered environment and constant presence of hosts allow ticks to become very abundant

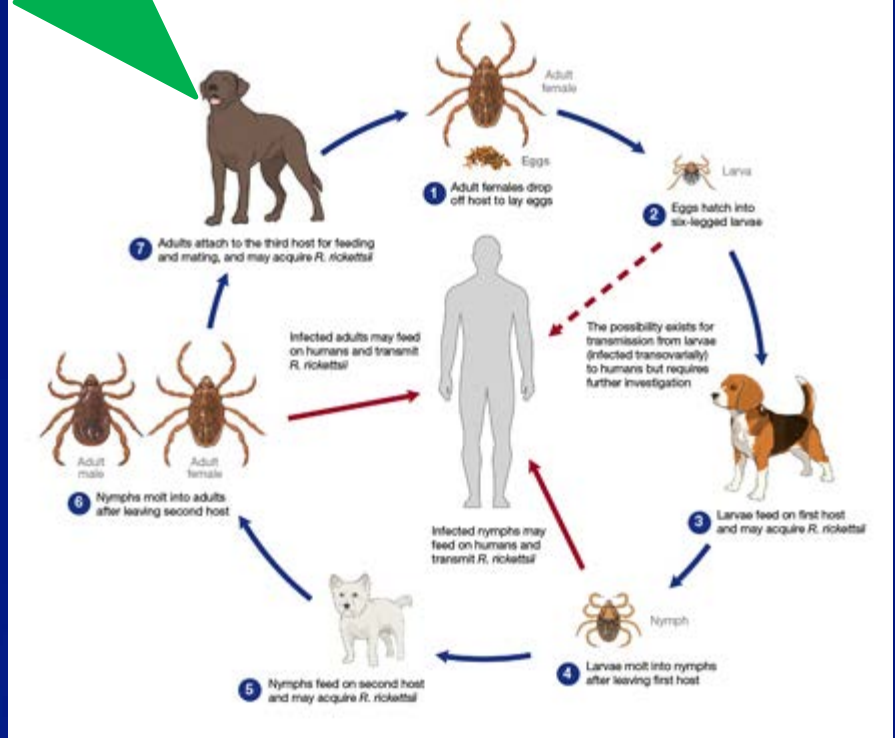
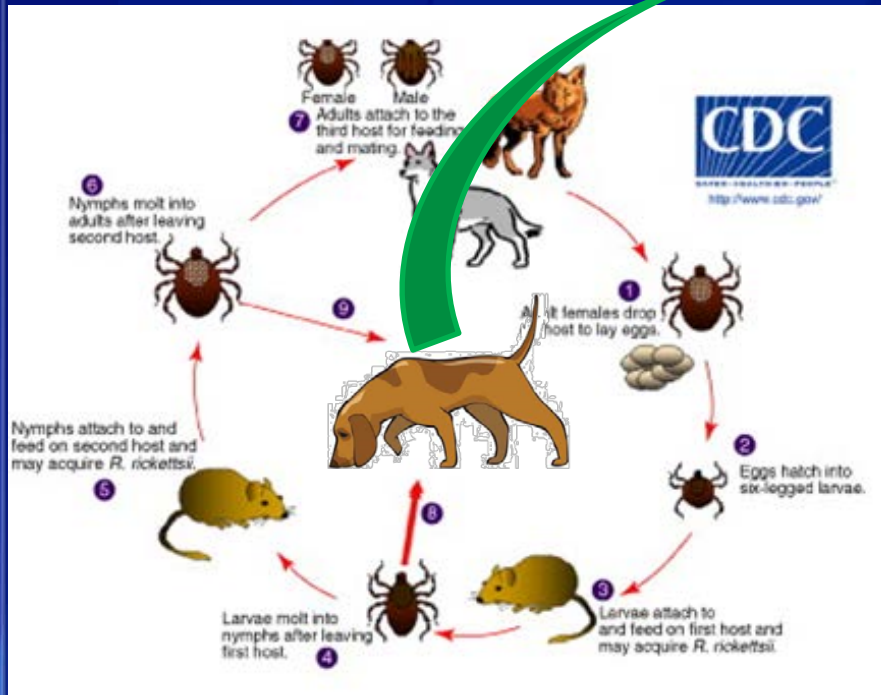


# Peridomestic cycle of *Rickettsia rickettsii*



- ❑ In areas where *Rhipicephalus* (the brown dog tick) is the primary vector, *Rickettsia* is passed between ticks and dogs.
- ❑ Humans can become infected when they are bit by either larvae, nymphs, or adult ticks.
- ❑ Infections can be frequent and concentrated, associated with particular village, neighborhood, even a household.

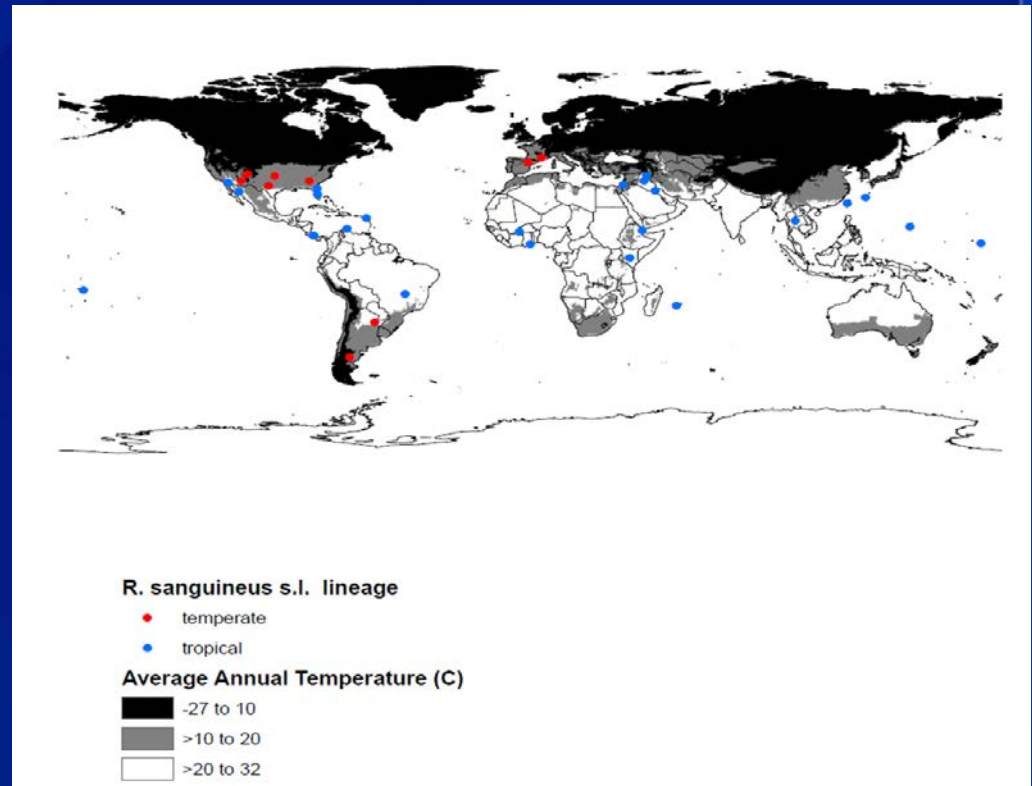
# Crossing natural cycles



- Crossing happens when an animal infected in a forest is brought into a domestic environment
  - a hunting dog attacked by brown dog ticks at home.

# Brown dog ticks are not the same

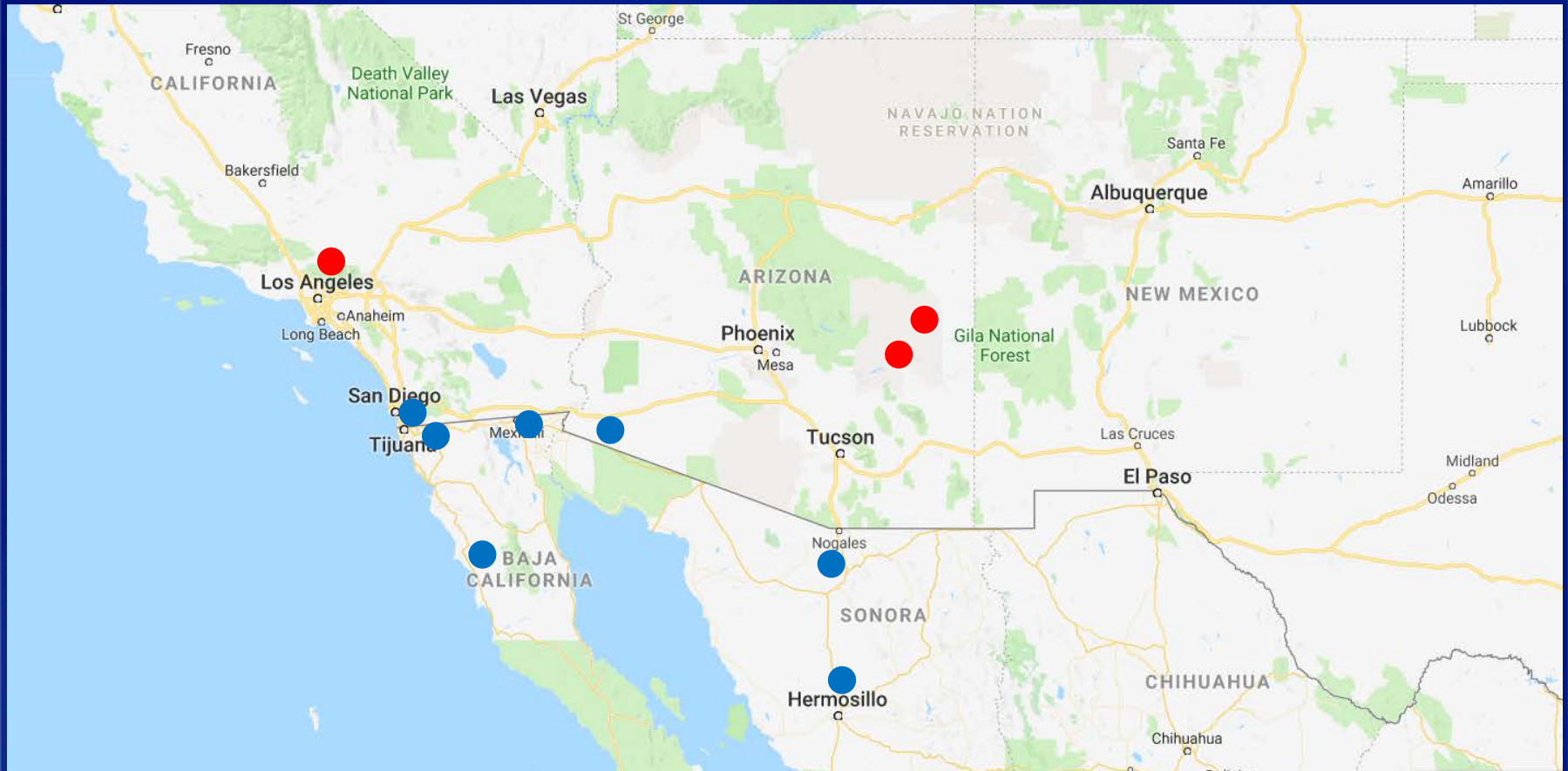
- The 2 lineages are segregated geographically
- May differ in their vector competence for different isolates of *R. rickettsii*



Zemtsova, G. E., et al. (2016). "Phylogeography of *Rhipicephalus sanguineus* sensu lato and its relationships with climatic factors." *Experimental & Applied Acarology* **69**(2): 191



# Brown dog ticks are not the same





# RMSF in Arizona, 2003-2016

- ❑ >380 cases including 23 deaths
- ❑ Incidence approximately 150 times the national average
- ❑ Peridomestic transmission
- ❑ Cases occur year-round, most deaths in children <10 years
- ❑ Maintained and transmitted by the brown dog ticks – *Rh. sanguineus* s.l.



# RMSF in Mexico

- ❑ Mid-1940s: Sinaloa, Sonora, Durango, and Coahuila
- ❑ Re-emergence of disease since early 2000s, particularly in northern states
- ❑ Case-fatality rates **as high as 80%**
- ❑ Cases occur in impoverished communities with free-roaming dogs
- ❑ **Different country, similar pathogen ecology**





# Dogs are susceptible to *Rickettsia rickettsii* infection

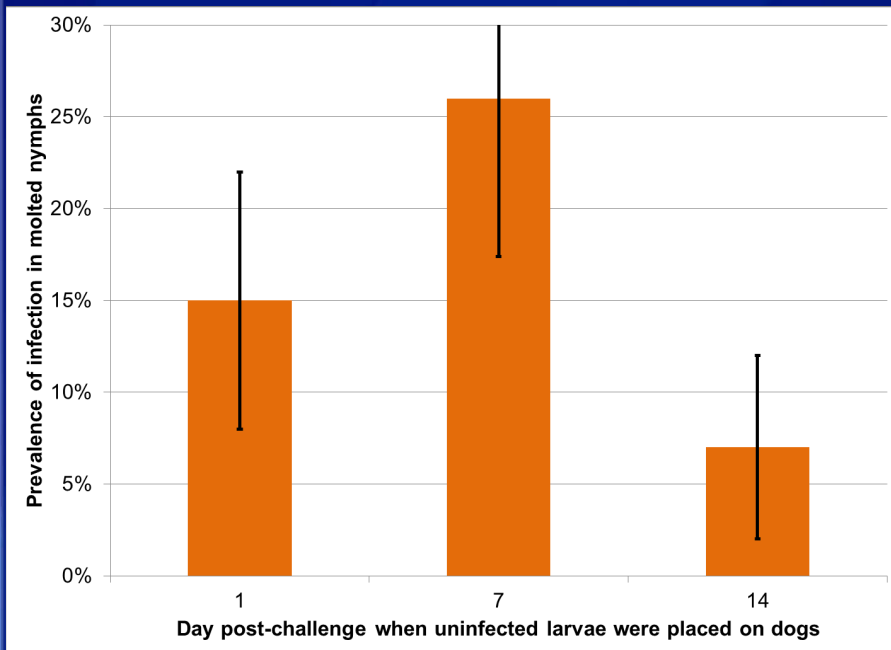


Clinical signs of rickettsial infection:

- weight loss, sluggishness
- Lack of appetite, dehydration
- high fever ( $>104^{\circ}\text{F}$ ),
- Red (blood-shut) eyes
- Rash on gums and exposed skin
- Swelling of testes in male dogs
- Tremors (uncontrollable shaking)
- Paralysis (leading to death)

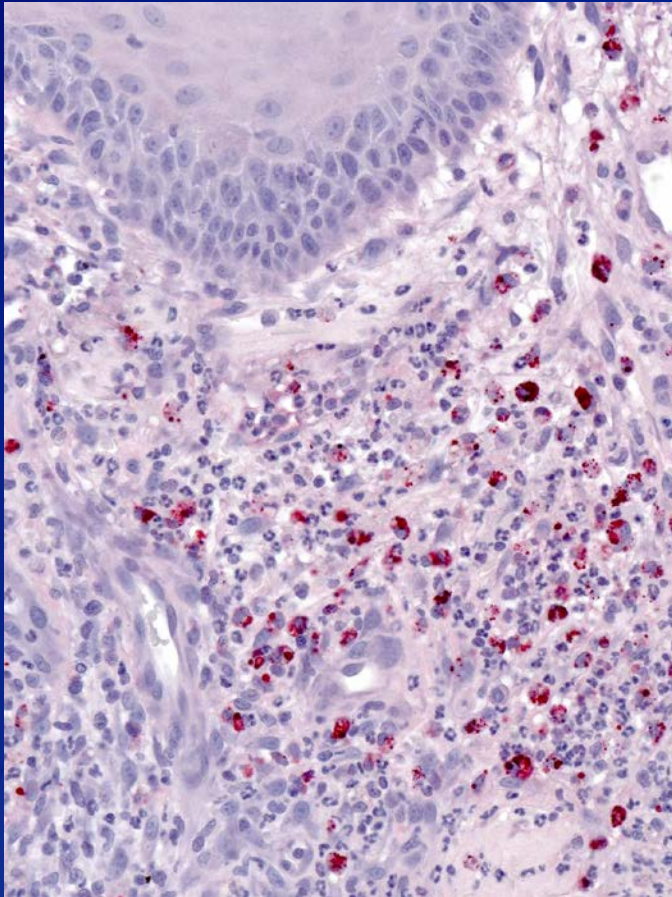
Recovery in untreated dogs depends on their health and immunity status.

# Dogs as reservoirs of *R. rickettsii* infection for ticks



- ❑ When brown dog ticks feed on infected dogs, they also become infected.
- ❑ The period when dogs are infectious for tick can last (in the laboratory) up to 3-4 weeks.
- ❑ During the peak of infection, up to 25-30% of ticks can become infected.

# Dogs can be re-infected

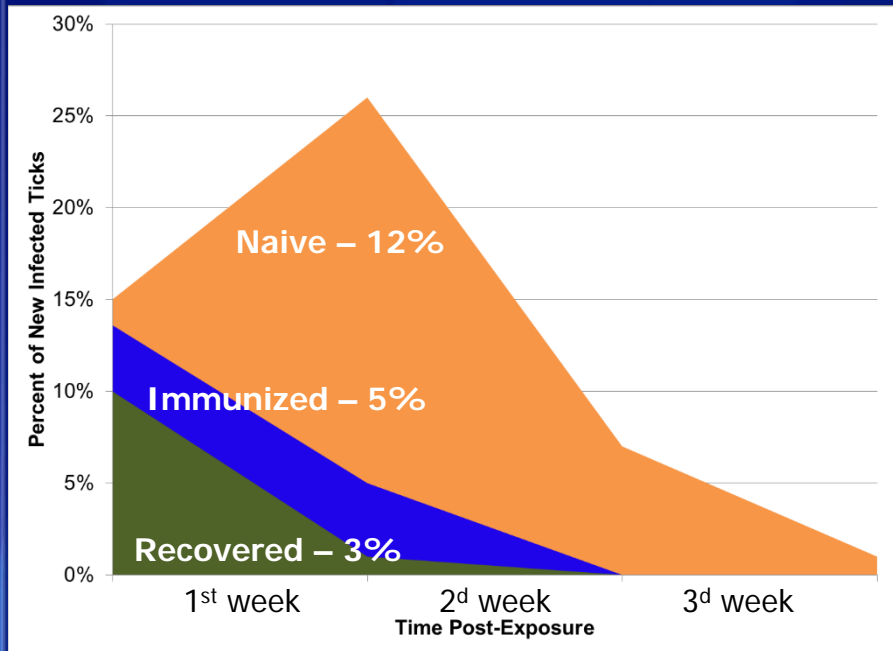


Skin sample from a SEROPOSITIVE @ 21 days after it was challenged by infected ticks.

- ❑ Antibodies against *R. rickettsii* in **dogs** disappear within 8-9 months after recovery.
- ❑ But **dogs** can be **re-infected even in the presence of antibodies** – as soon as in 2-3 months
- ❑ Re-infection results in few and milder clinical signs

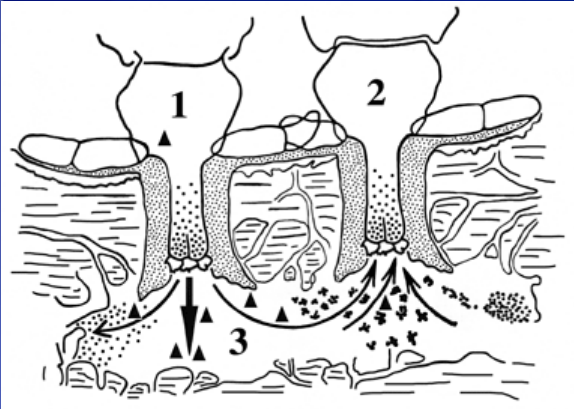


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- ❑ Re-infection results in few and milder clinical signs
- ❑ => dog appears healthy but is producing infected ticks. Continued tick control is key!

# Transmission of *Rickettsia* between Co-feeding ticks



- ☐ *Rickettsia* can also pass from an infected tick to uninfected ticks when they are feeding simultaneously on the same host.
- ☐ This happens even if animal is not sick.
- ☐ In *Rh. sanguineus*, adult and immature ticks often feed simultaneously on the same individual animals in large numbers.
- ☐ This route of transmission can be blocked (only) by reduction of the number of ticks feeding together on a dog.

# Seasonal activity of the brown dog tick



- ❑ Efforts to reduce tick abundance are more successful and efficient if applied at the appropriate time – when ticks are active.
- ❑ A year-long study of the tick seasonal activity San Carlos reservation - 2011-2012.

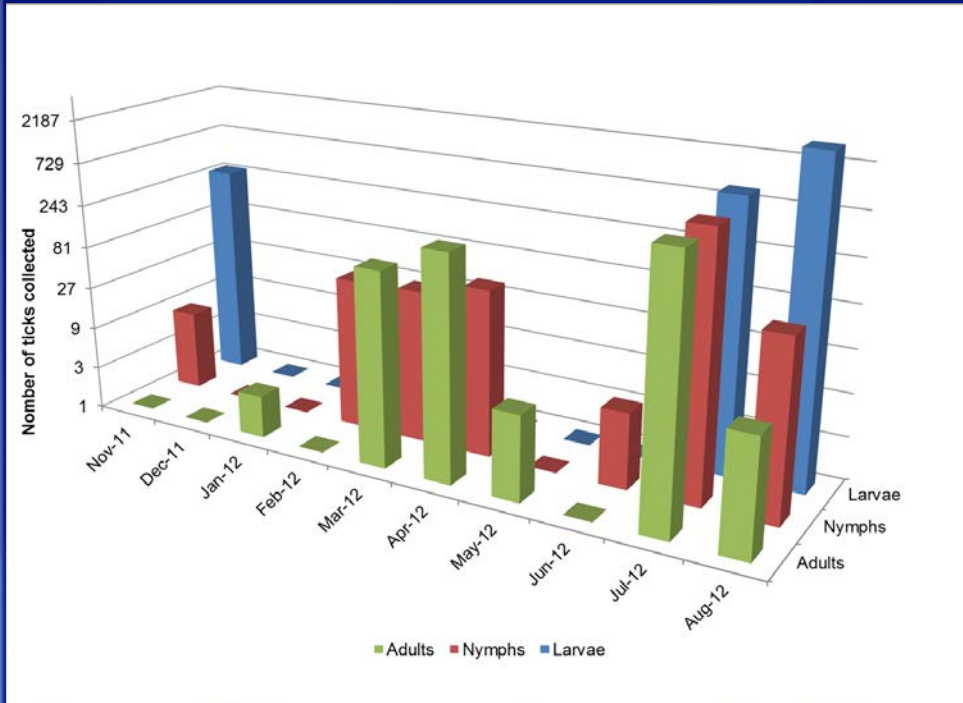
# Seasonal activity of the brown dog tick



- ❑ Every month, team put out CO<sub>2</sub> traps at 4-6 houses.
- ❑ White cloths (3/house) are placed where dogs often rest or sleep.
- ❑ A container with dry ice is placed in the center of the cloth.
- ❑ Ticks attracted to CO<sub>2</sub> crawl onto the cloth.
- ❑ After 3-4 hours, the cloths are folded and sent to the lab., where ticks counted.



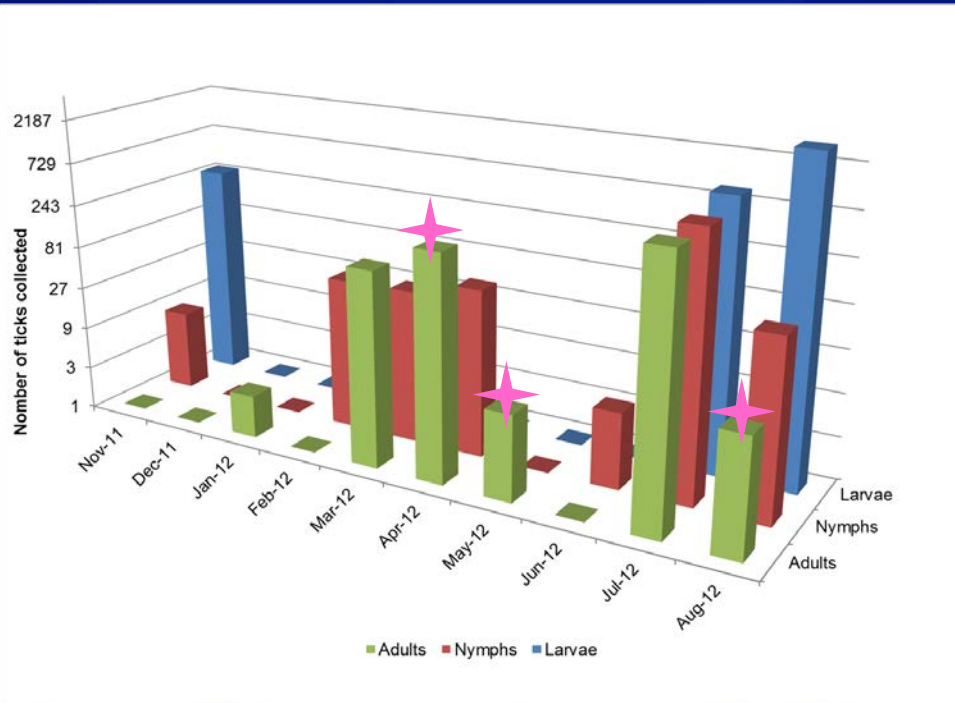
# Seasonal activity of the brown dog tick



- ❑ Ticks were active practically all year-long;
- ❑ The highest numbers ticks observed in early-mid spring and mid-late summer;
- ❑ Continuous tick-control efforts are needed from March through August;
- ❑ There are at least 2 generations per year → the potential for development of acaricide resistance is x2 higher than in *Dermacentor* spp.



# Distribution of *Rickettsia* in brown dog ticks

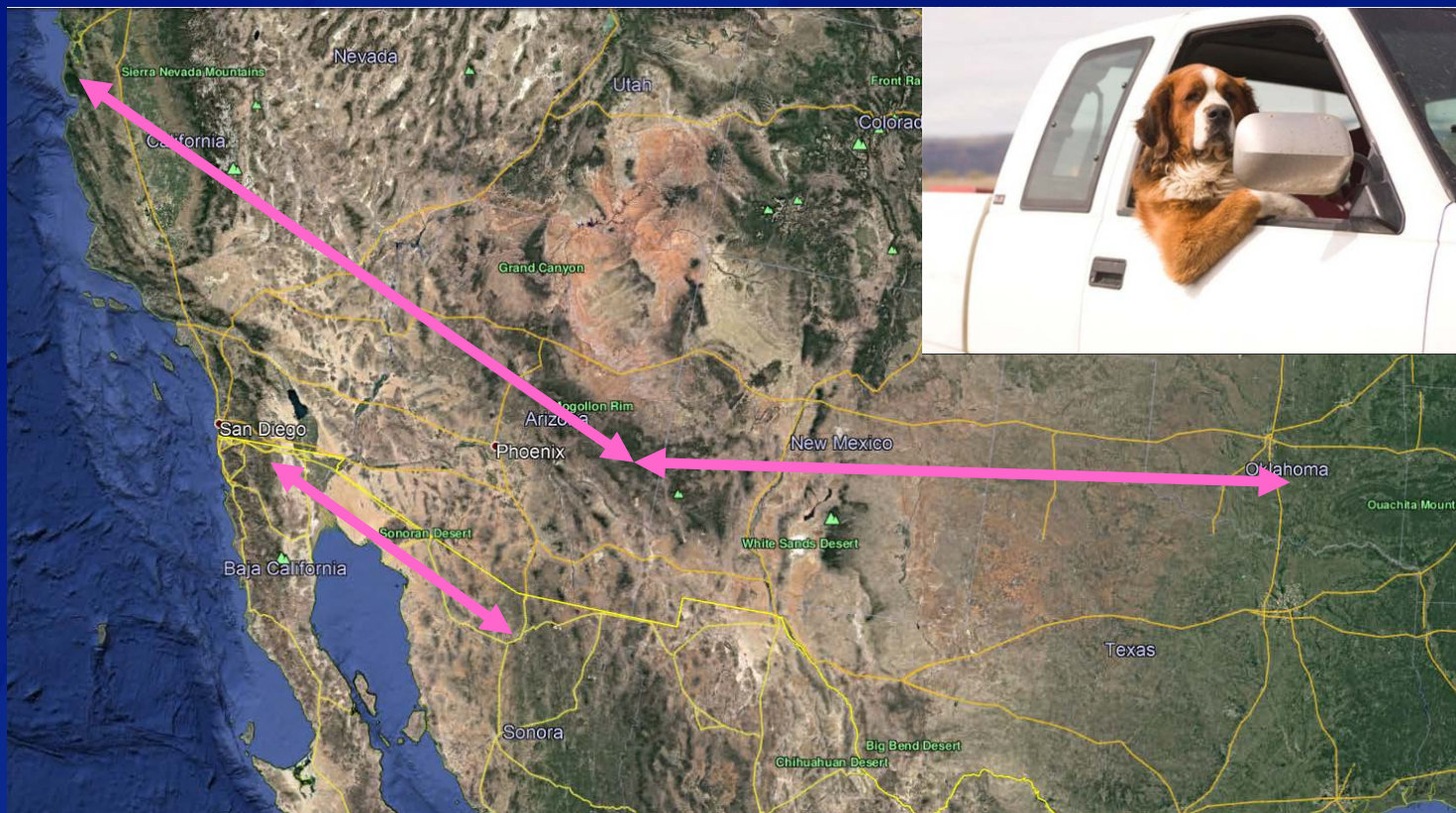


- ❑ Tested ticks for *R. rickettsii*;
- ❑ Infected ticks were found on 3 occasions – each time in ticks from a different house;
- ❑ Not finding infected ticks at other times or houses **DOES NOT MEAN** absence of *Rickettsia* in the neighborhood, only that we did not see it.

# Where did the ticks come from?

- ❑ In 2011, collected ticks from 1-4 dogs per neighborhood across Fort Apache Reservation;
- ❑ Tested DNA and compared to brown dog ticks from other locations.
- ❑ There are at least 2 clades of *Rhipicephalus sanguineus* represented within one reservation - One, closer to those in California, and one to those closer in Oklahoma.
- ❑ Moreover, ticks from Fort Apache are not closely related to ticks from San Carlos
- ❑ Tick infestation at each Reservation is a result of multiple separate introductions from different locations.

# Where did the ticks come from?



- ❑ Similar situation in Arizona and Sonora, MX
- ❑ As dogs don't normally roam 100s of miles themselves, these long-distance tick exchanges are facilitated by people.

# Bottom Line

- ❑ Different vectors = different cycles of transmission, risk factors, frequency of human infections, ...
- ❑ Even dogs that had been sick in the past can become infected again and produce infected ticks
- ❑ Transmission cycle can be broken only by reducing numbers of ticks feeding on dogs
- ❑ Free-roaming dogs carry and spread ticks from house to house and between neighborhoods; undermine tick-control efforts
- ❑ Brown dog ticks can travel long distances on dogs or even in household items => ALL traveling, visiting, introduced dogs should be checked and treated
- ❑ Tick-control efforts need to be sustained – failure to do so will only expedite development of acaricide resistance.



# Questions?



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