# Tick Talk:
# Advancing the Understanding and Prevention of Tick-borne Diseases

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UCSF Dept of Biochemistry & Biophysics
Osher Mini Med School, 11/14/19

Malaria

Sleeping sickness

Lyme disease

# Topics:

1. Ticks and their vector capacity
2. Challenges associated with diagnosing Lyme
3. Strategies for blocking tick-borne diseases
4. What else can we learn from ticks?

# Ticks are vectors for human diseases

*Ixodes scapularis*
*Ixodes pacificus*

Lyme Disease
Anaplasmosis
Babesiosis
Powassan Disease

*Dermacentor andersoni*
*Dermacentor variablis*

Rocky Mountain Spotted Fever
Colorado Tick Fever

*Amblyomma maculatum*
*Amblyomma americanum*

Ehrlichiosis
Rickettsiosis
Mammalian Meat Allergy

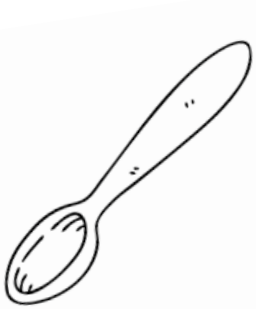
# Different ticks have different lifestyles

Hard

Soft

capitulum

scutum



*Ixodes scapularis*

*Ornithodoros savignyi*

# Different ticks have different lifestyles

Hard

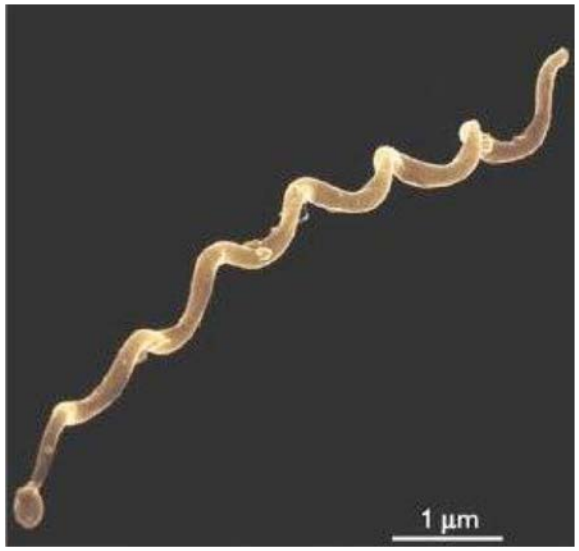
*Ixodes scapularis*

- 3 stages: larvae, nymphs, adults
- Single bloodmeal between each
- Bloodmeal: days to over a week

# Lyme disease cases in the U.S. are on the rise

*Ixodes scapularis*

*Borrelia burgdorferi*



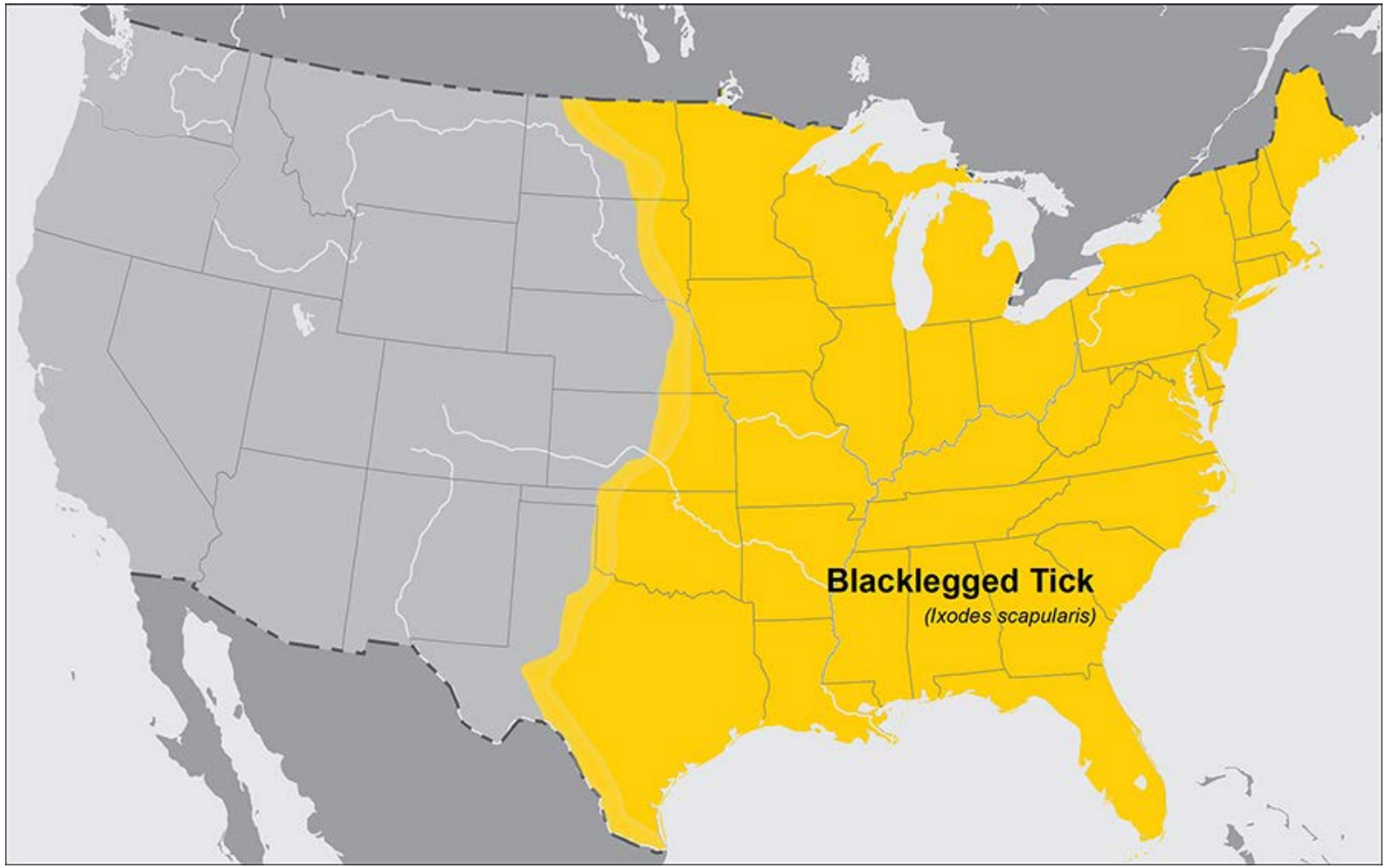

Lyme disease

Cases have tripled in past decade

Most commonly reported vector-borne disease in U.S.

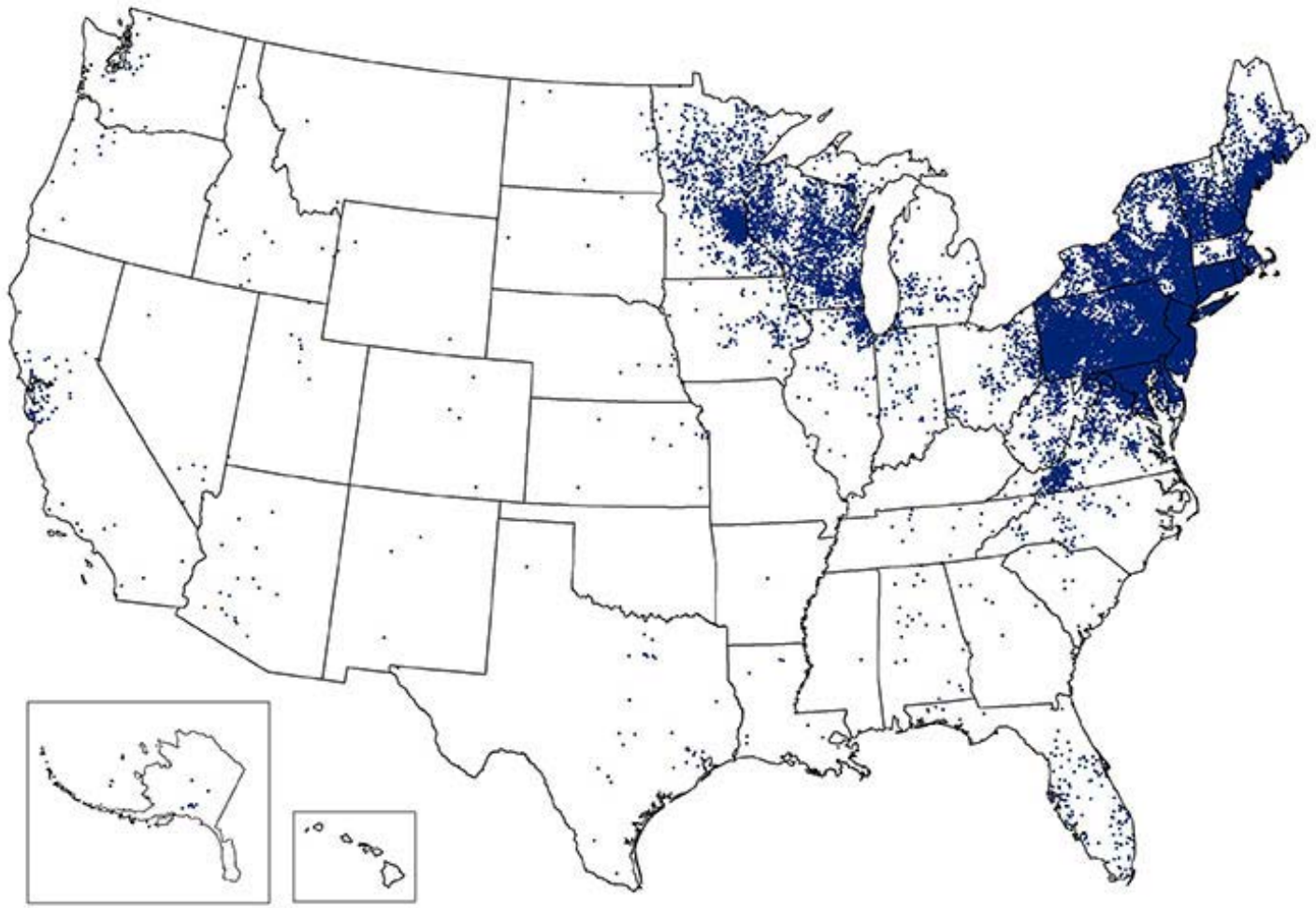
Centers for Disease Control

# Tick–pathogen relationships are remarkably specific




Source: CDC.gov

# Lyme disease is restricted to where tick vectors are



1 dot placed randomly within county of residence for each confirmed case

Source: CDC.gov

# West coast vector: *Ixodes pacificus*

Western blacklegged tick

# West coast vector: *Ixodes pacificus*

*Sceloporus occidentalis*

Western fence lizard

PLOS ONE

RESEARCH ARTICLE

# Using citizen science to describe the prevalence and distribution of tick bite and exposure to tick-borne diseases in the United States

Nathan C. Nieto[1]*, W. Tanner Porter[1], Julie C. Wachara[1], Thomas J. Lowrey[1], Luke Martin[2], Peter J. Motyka[1], Daniel J. Salkeld[2]

Porter *et al. Int J Health Geogr* (2019) 18:9
https://doi.org/10.1186/s12942-019-0173-0

International Journal of Health Geographics

RESEARCH Open Access

# Citizen science informs human-tick exposure in the Northeastern United States

W. Tanner Porter*, Peter J. Motyka, Julie Wachara, Zachary A. Barrand, Zahraa Hmood, Marya McLaughlin, Kelsey Pemberton and Nathan C. Nieto

Contents lists available at ScienceDirect

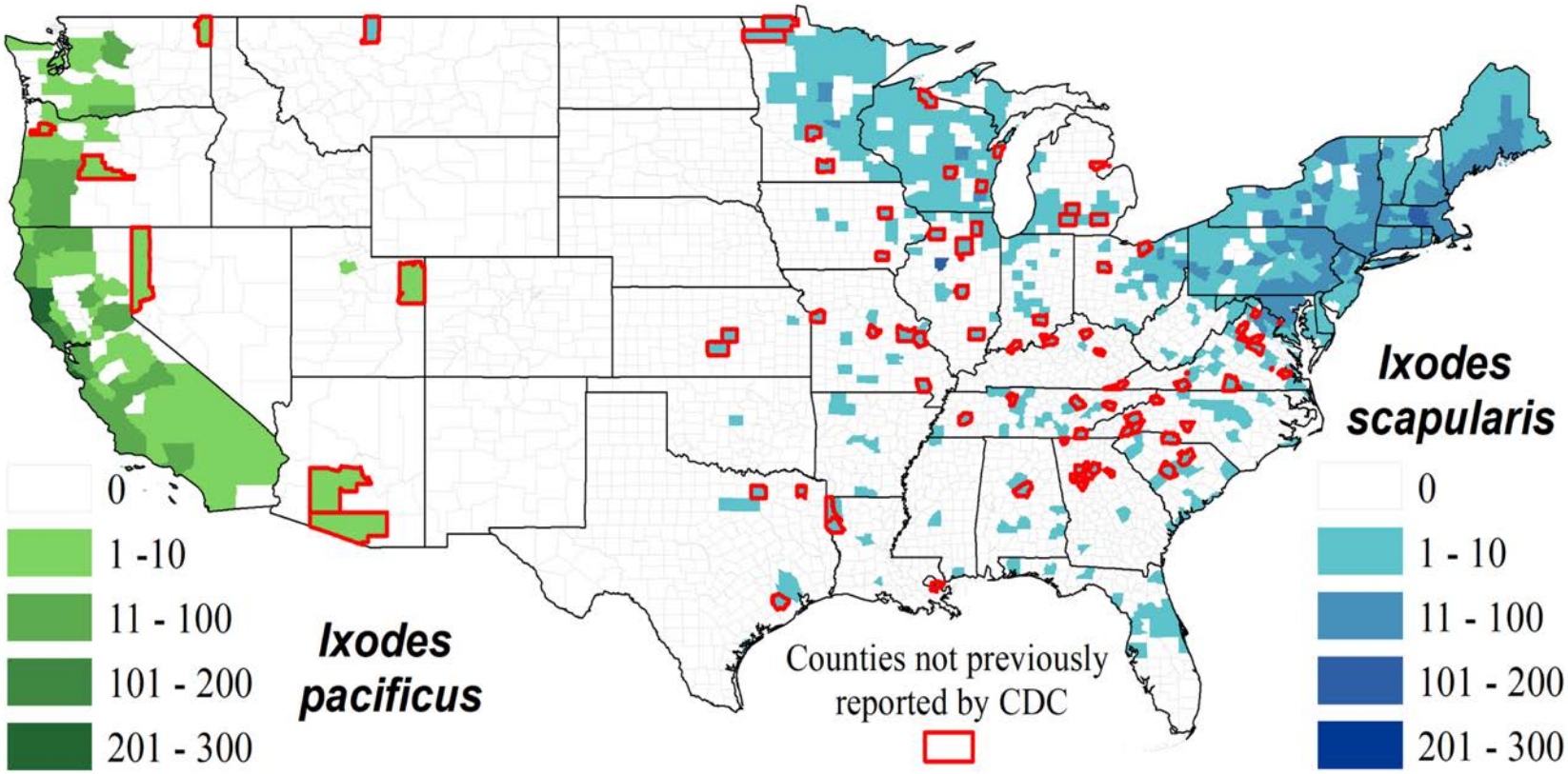
Ticks and Tick-borne Diseases

journal homepage: www.elsevier.com/locate/ttbdis

# Time of year and outdoor recreation affect human exposure to ticks in California, United States

Daniel J. Salkeld[a,b,*], W. Tanner Porter[c], Samantha M. Loh[b], Nathan C. Nieto[c]

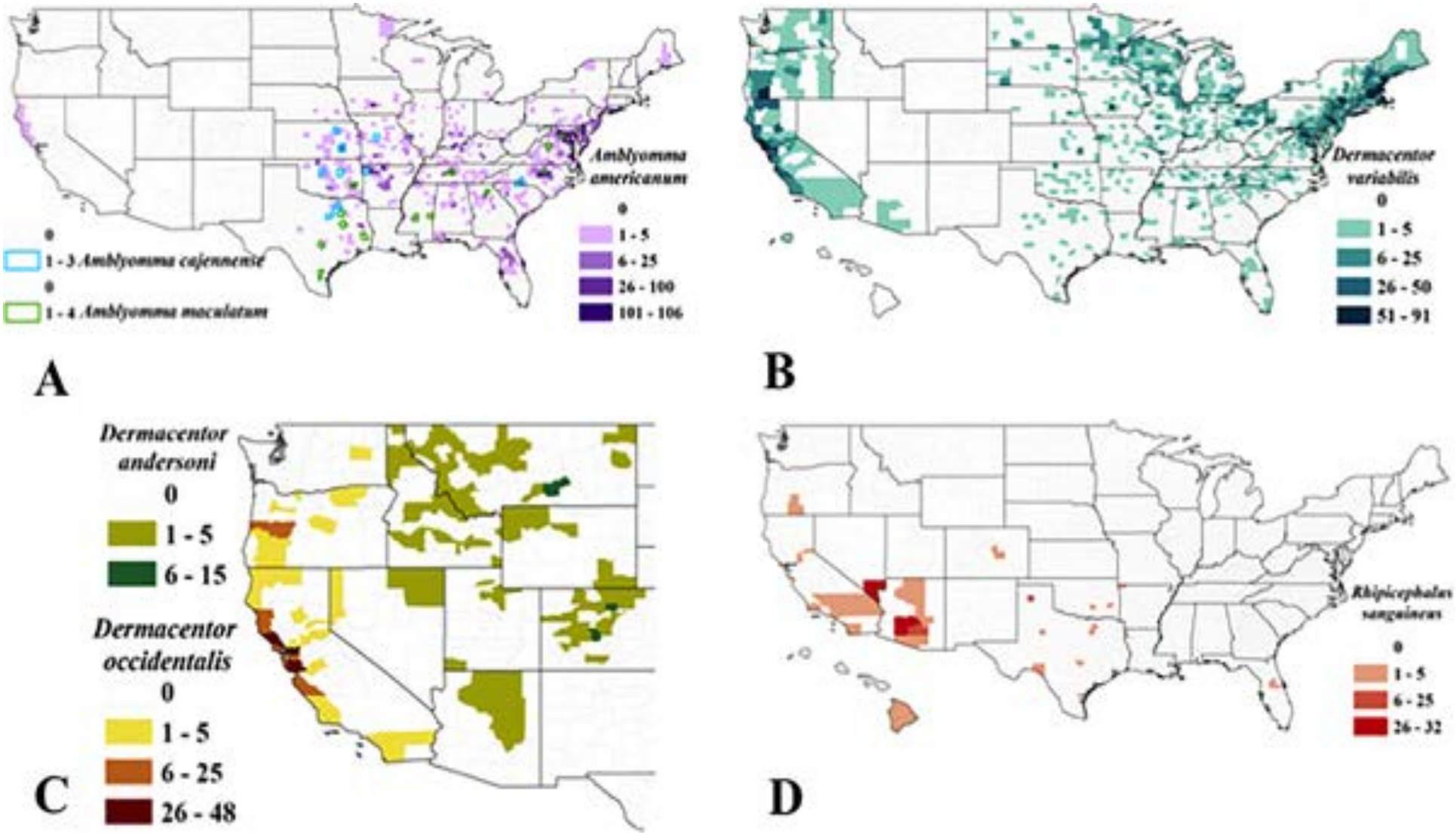
# County level distribution of submitted *Ixodes*




doi: https://doi.org/10.1371/journal.pone.0199644.g002

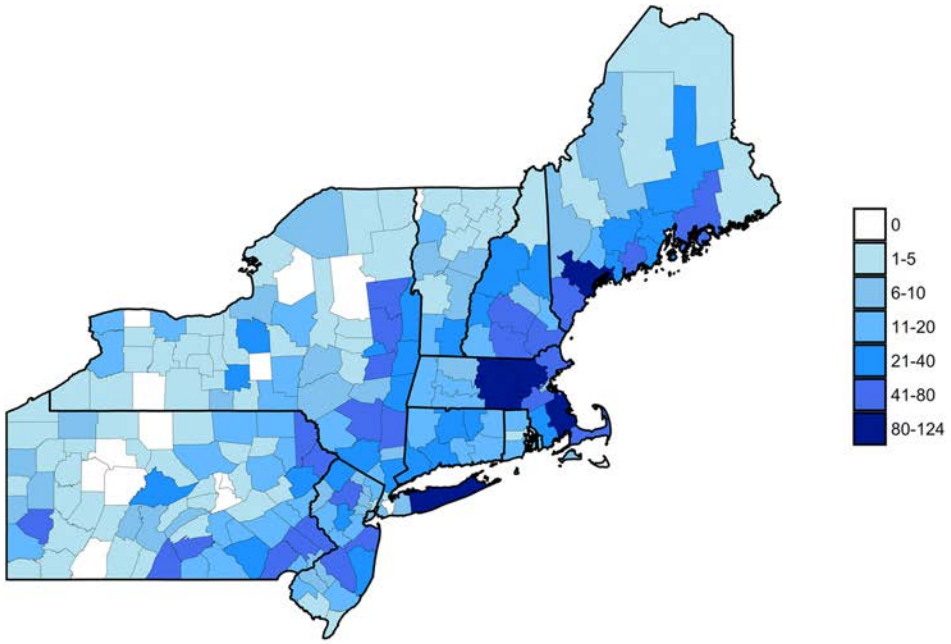
Nieto et al, 2018

# Distribution of other tick species received

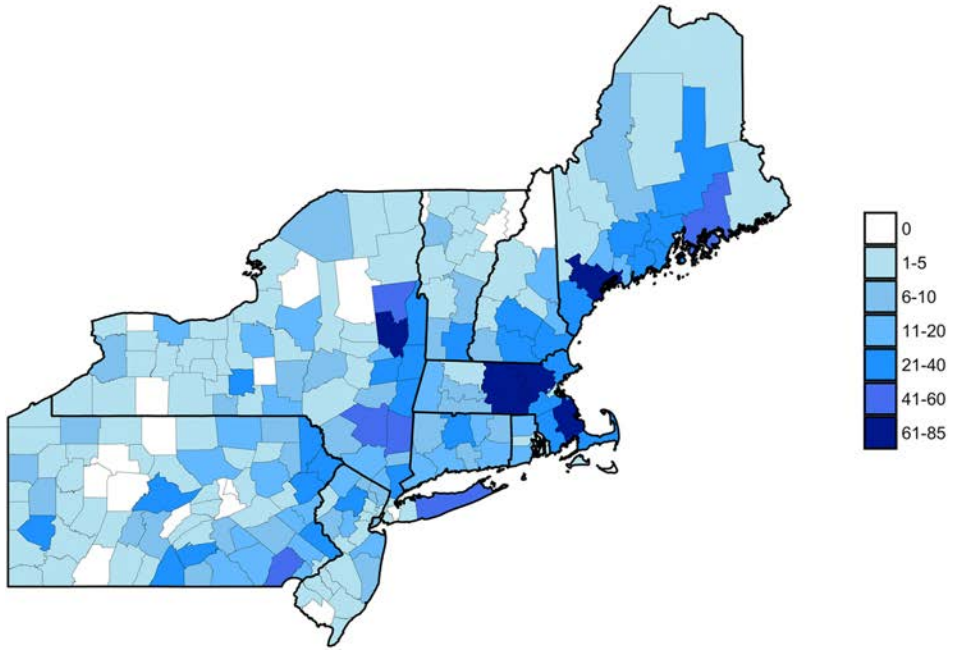



Nieto et al, 2018

# Questing/biting ticks collected from humans in NE




All submissions
(4261)

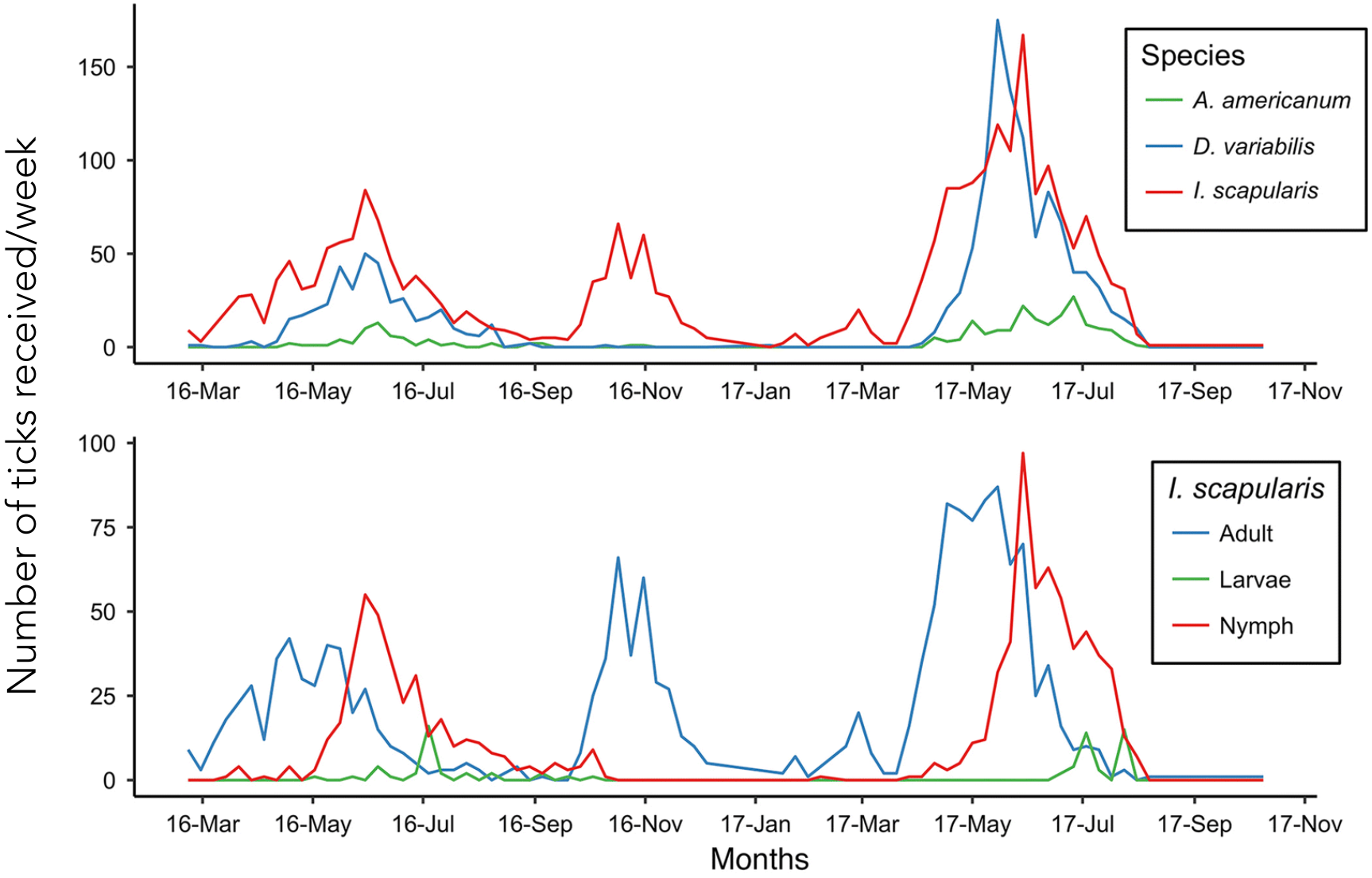



*Ixodes scapularis*
(2574, 60%)

*Dermacentor variablis* 33%; *Amblyomma americanum* 2%

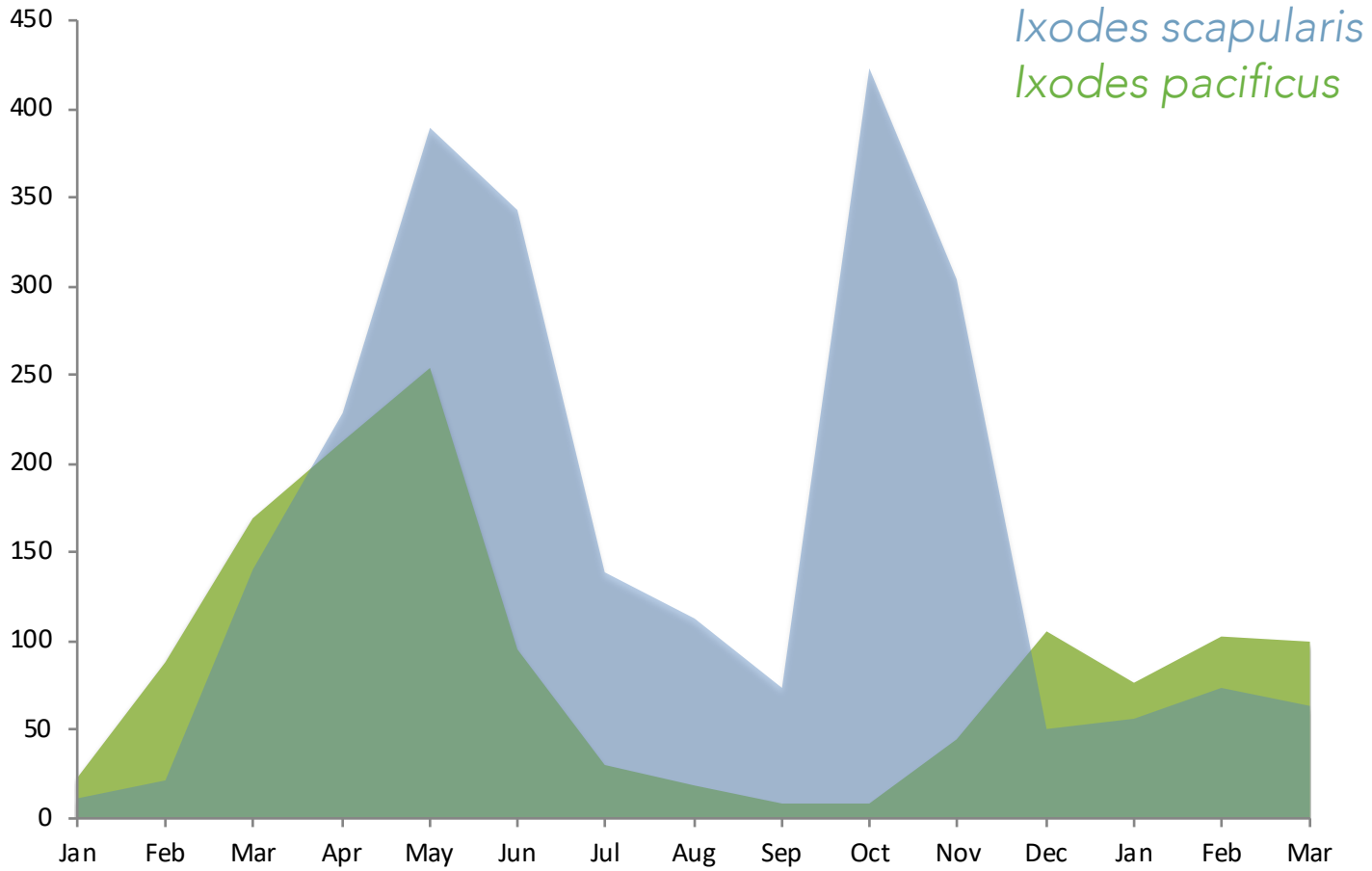
Porter et al, 2019

# Submissions varied by species, stage, season




Porter et al, 2019

# *Ixodes* species also had different collection patterns



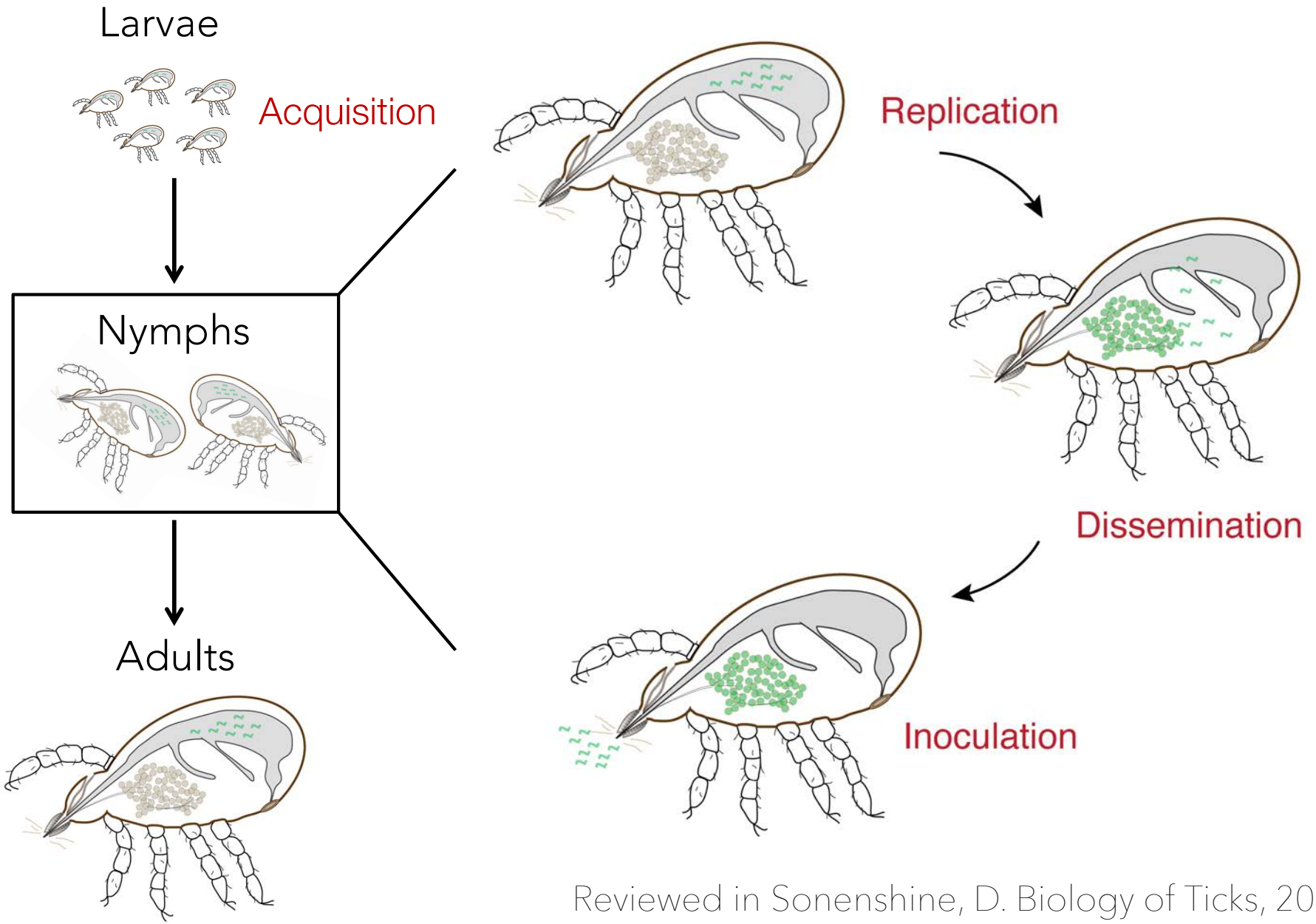

Courtesy of Wendy Adams, Nate Nieto

Vector capacity = ecology + competence

Vector competence

*Intrinsic ability to acquire, carry, and transmit microbes.*

# *B. burgdorferi* transmission cycle




Reviewed in Sonenshine, D. Biology of Ticks, 2014 ed.

# Topics:

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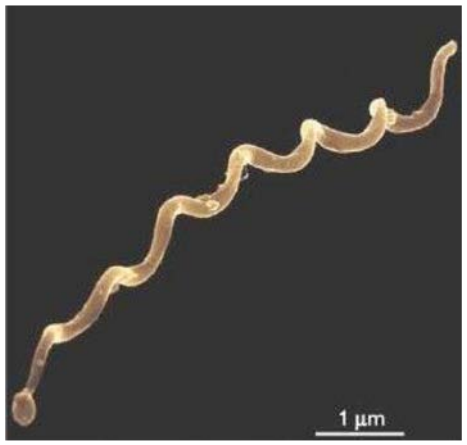
# Lyme disease is difficult to diagnose/treat




*Borrelia burgdorferi*

Arthritis, fatigue, neurodegeneration

Incubation period: 3-32 days

Limited window for treatment

Difficult to detect in blood

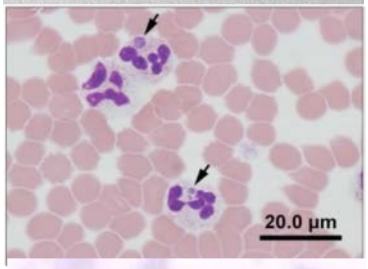
Unsuccessful vaccine (2002)

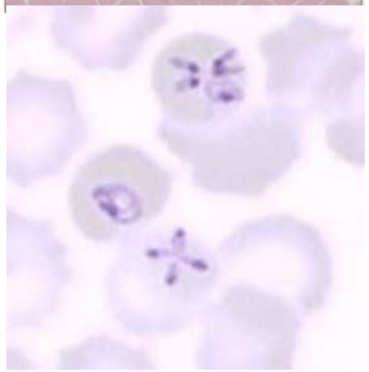
# Ticks can carry multiple pathogens

Nationwide

| | |
|---|---|
| *Borrelia burgdorferi sl* | 6.14% |
| *Borrelia miyamotoi* | 0.91% |
| *A. phagocytophilum* | 1.76% |
| *Babesia microti* | 0.66% |

**Ehrlichia* and *Rickettsia* spp.,
high prevalence in some places (~40%)



Coinfections

Bb + Bm (N = 11)
Bb + Ap (N = 14)
Bb + Bab (N = 8)

Bm + Ap (N = 1)
Bm + Bab (N = 2)

Ap + Bab (N = 1)

Tri-infection

Bb + Bm + Bab (N = 3)
New York and Pennsylvania
Bb + Ap + Bab (N = 1)
Minnesota

Courtesy of Wendy Adams, Nate Nieto

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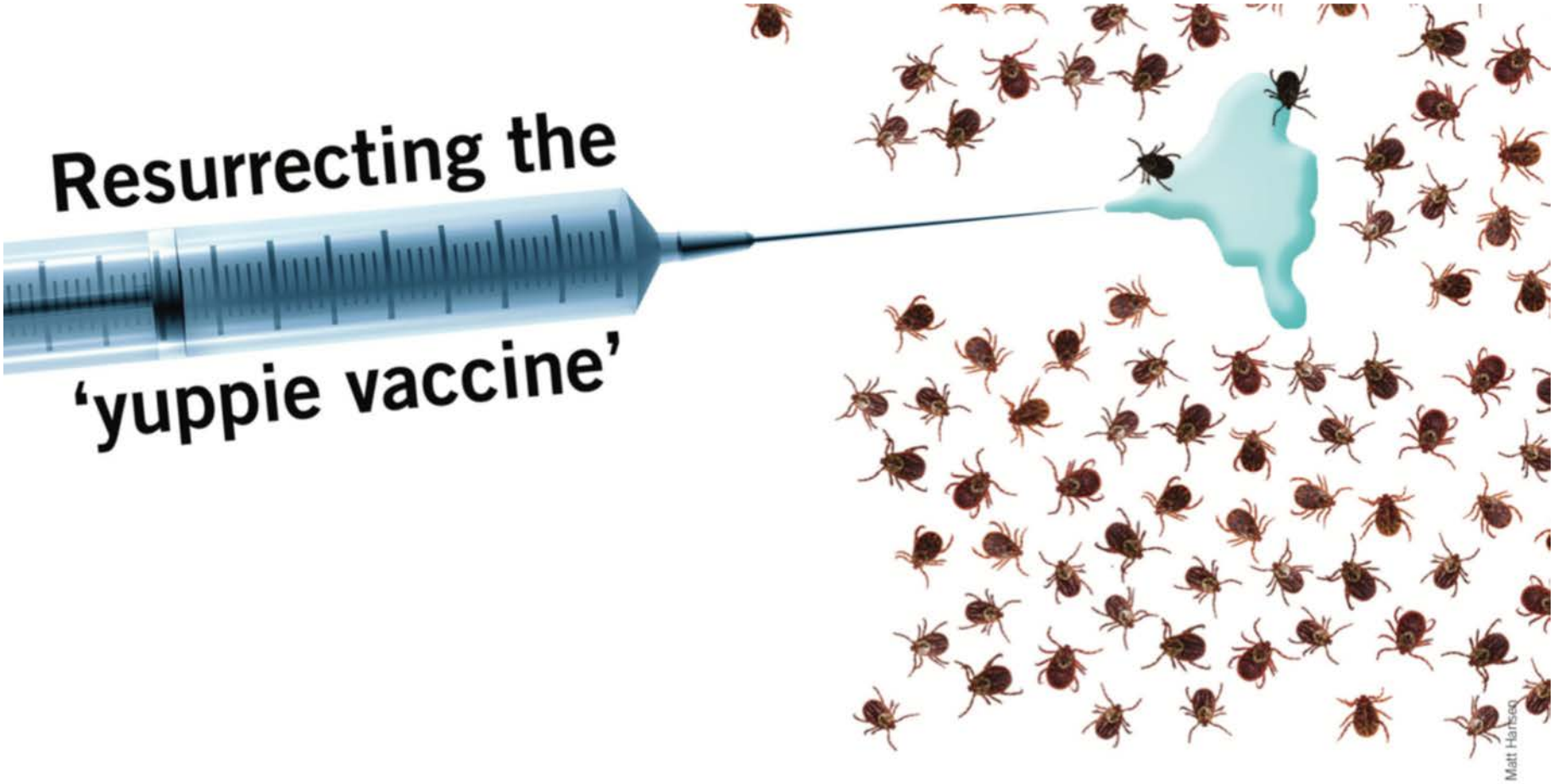
# Resurrecting the ‘yuppie vaccine’




The only vaccine ever approved to protect against Lyme disease was pulled off the market in 2002, and drugmakers have yet to offer an alternative. What’s taking so long? **Cassandra Willyard** investigates.

*Nature Medicine*, 2014

# Paratransgenesis to control vectors

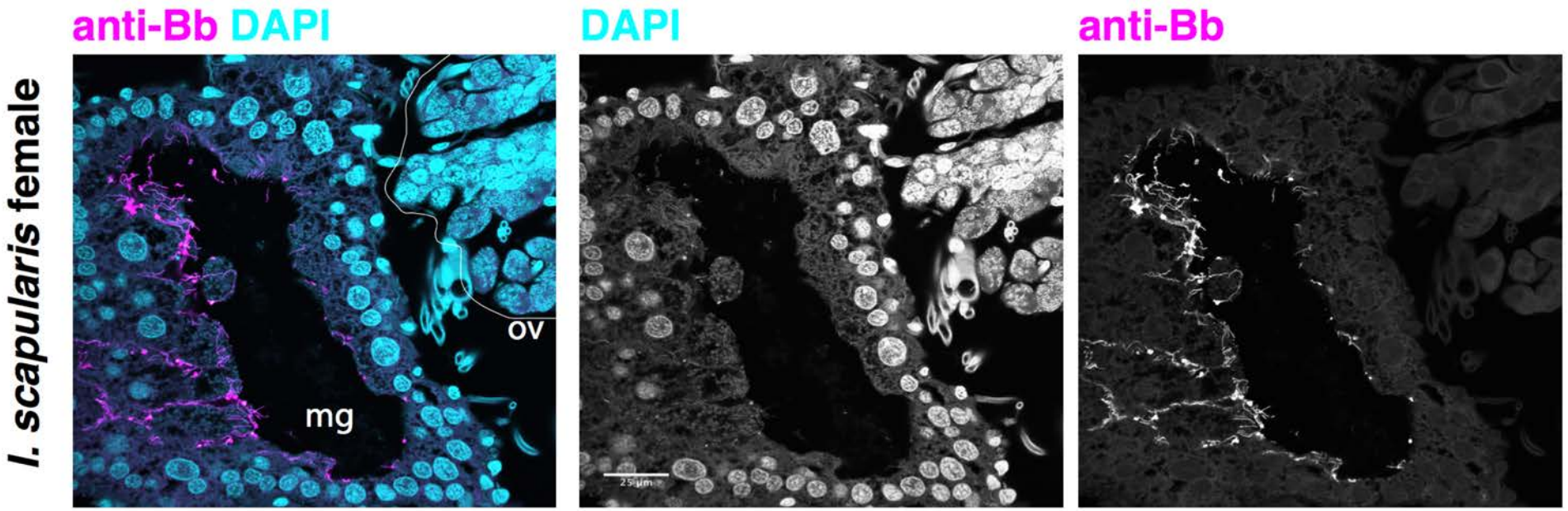
*Aedes aegypti*

*A. aegypti* mosquitoes transmit Zika virus

(also dengue, chikungunya, yellow fever)

Infect with bacterium *Wolbachia*

# The Lyme pathogen is in gut of *I. scapularis* ticks

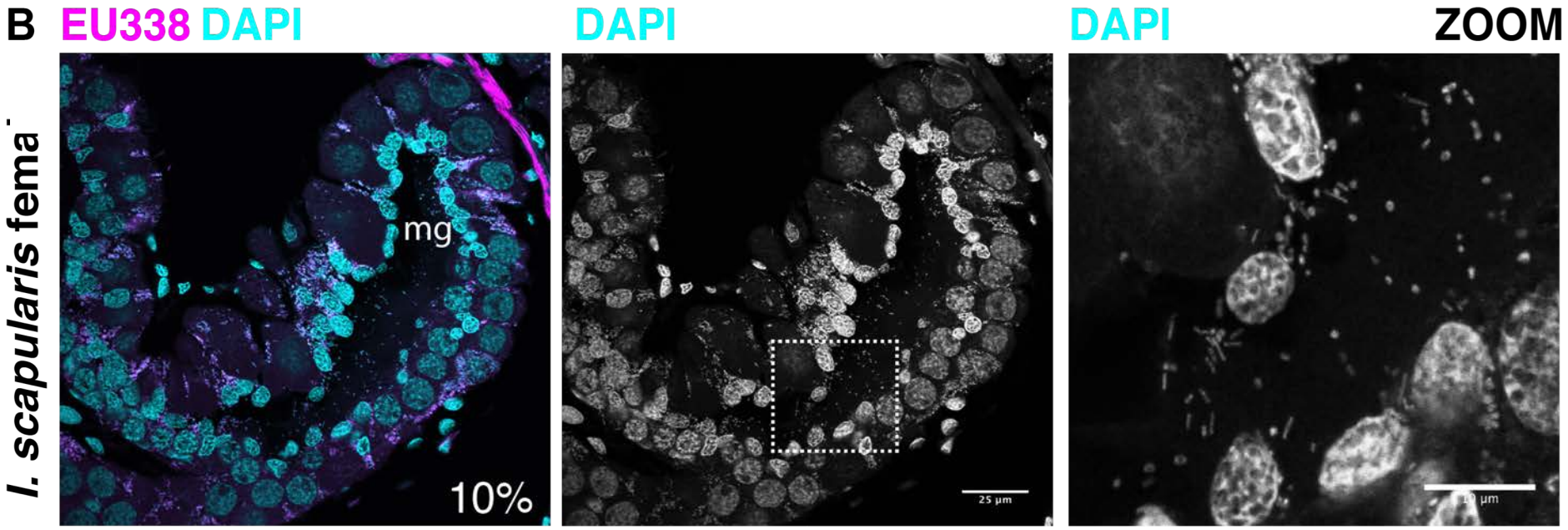



mg = midgut

ov = ovary

Ross B et al, *ISME* (2018)

# Some ticks have other kinds of bacteria




Negatively correlates with *B. burgdorferi*

Ross B et al, *ISME* (2018)

RESEARCH ARTICLE

LEISHMANIASIS

# A sand fly salivary protein vaccine shows efficacy against vector-transmitted cutaneous leishmaniasis in nonhuman primates

Fabiano Oliveira,[1] Edgar Rowton,[2] Hamide Aslan,[1]* Regis Gomes,[1,3] Philip A. Castrovinci,[1] Patricia H. Alvarenga,[4,5] Maha Abdeladhim,[1] Clarissa Teixeira,[1,3] Claudio Meneses,[1] Lindsey T. Kleeman,[1] Anderson B. Guimarães-Costa,[1] Tobin E. Rowland,[2] Dana Gilmore,[1] Seydou Doumbia,[6] Steven G. Reed,[7] Phillip G. Lawyer,[2] John F. Andersen,[8] Shaden Kamhawi,[1†] Jesus G. Valenzuela[1†]

# Topics:

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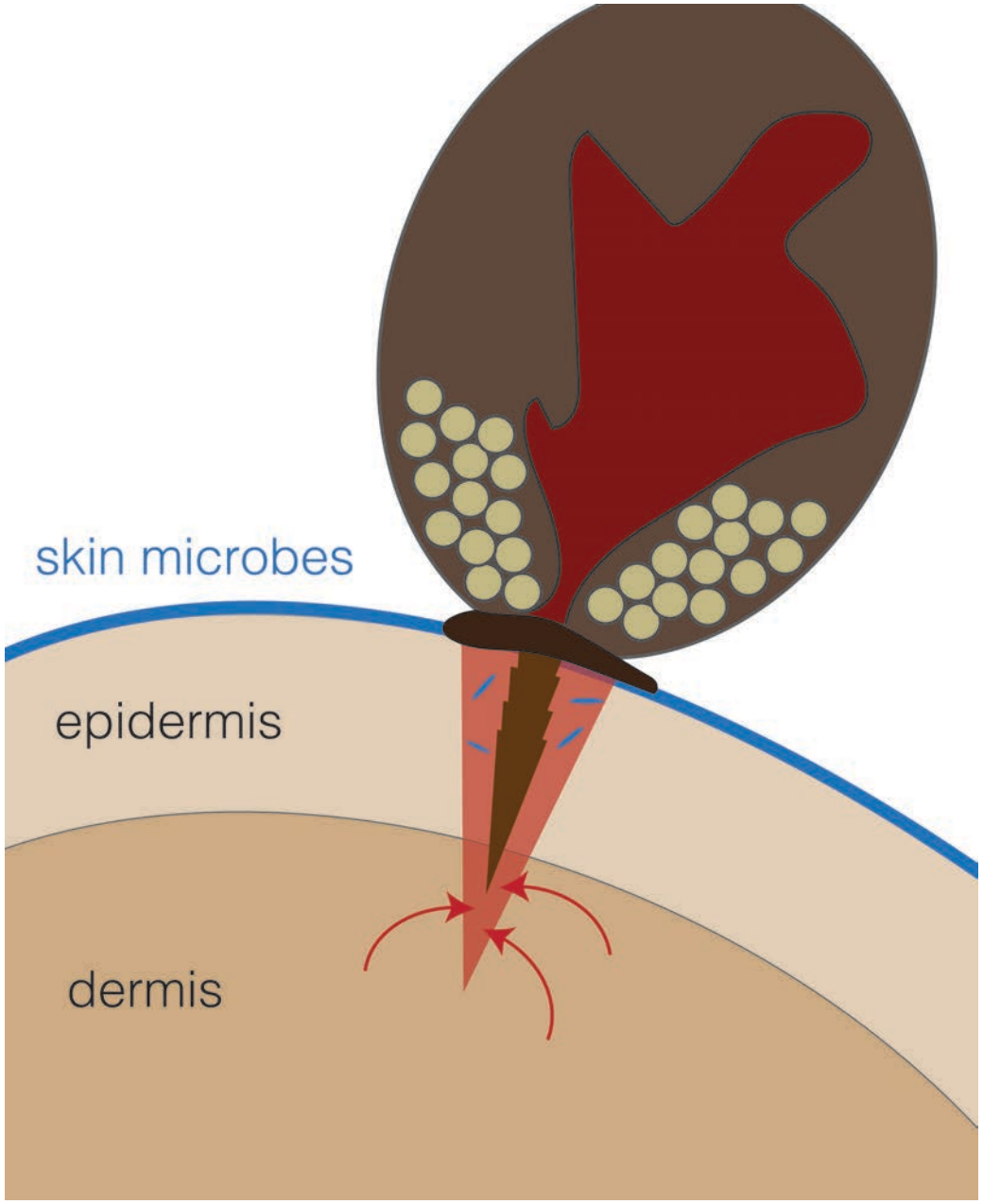
# Ticks are master regulators of us (their food)

# Both ticks and pathogens rely on saliva



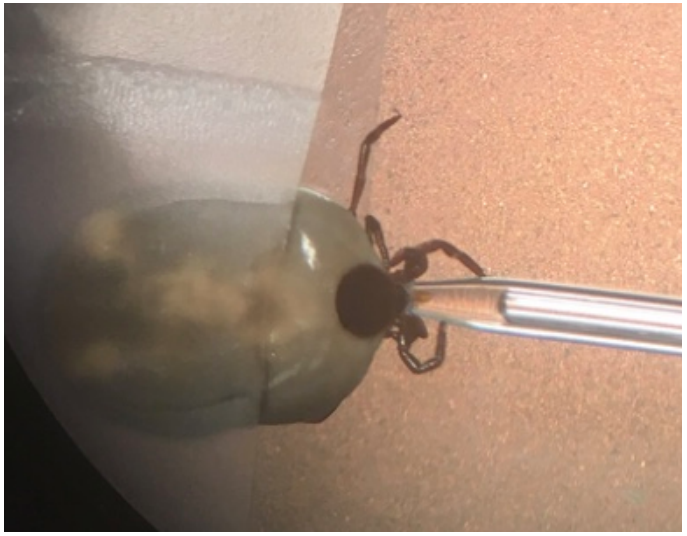

Pool feeders

Prolonged bloodmeals

90% of fluid is secreted

Saliva-activated transmission

# Adventures in collecting tick spit



~$10^2$ proteins in sialome

Composition changes over time

Arthropod saliva is protease-rich

Questions?