

Tick Ecology for Epidemiologists

CSTE Vectorborne Diseases Subcommittee Webinar Series
December 15, 2015
2:00-3:00 pm Eastern



Council of State and Territorial Epidemiologists

Webinar Housekeeping



Webinar Housekeeping

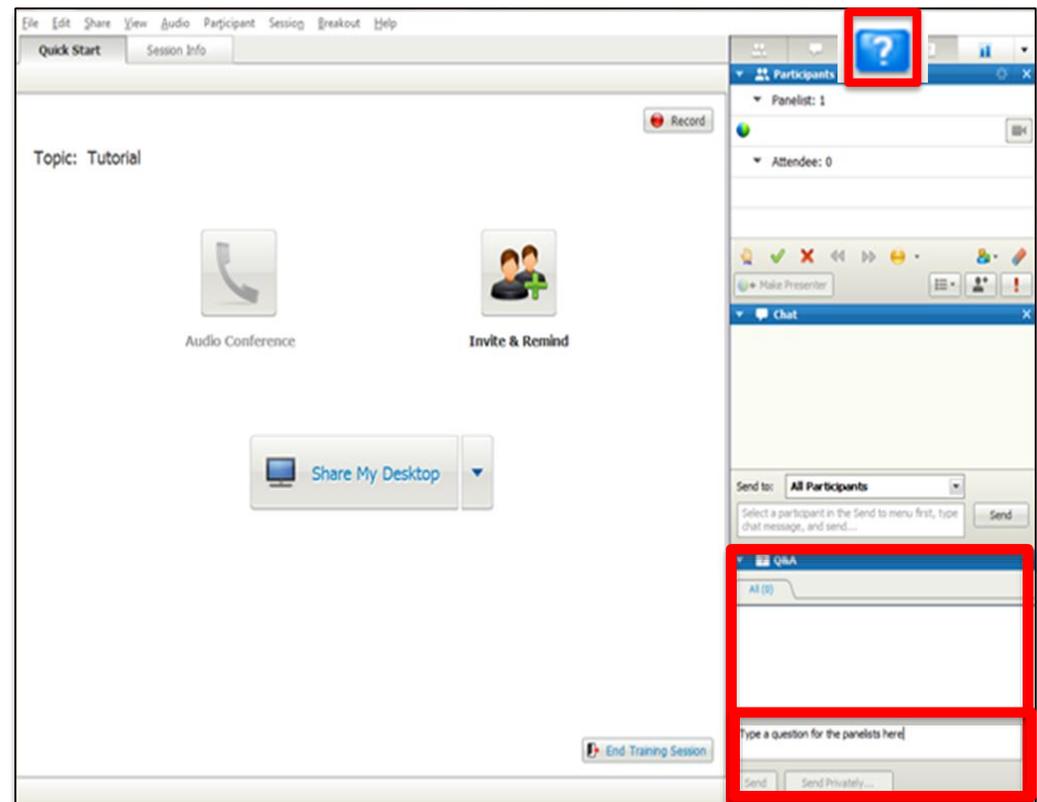


- Please note that today's webinar is being recorded
 - The webinar recording and presentation slides will be available in the webinar library on CSTE's website:
<http://www.cste.org/?page=WebinarLibrary>
- All phone lines have been placed on mute
- There will be a question-and-answer session at the end of the webinar
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To Ask a Question



- Click on the blue question mark tab on the top right panel of your screen
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- Type a question
- Send questions to All Panelists
- Questions will be answered during the Q&A period



Learning Objectives



By the end of the webinar, participants will be able to:

- Describe what ticks are
- Explain why tick taxonomy and systematics might be important for epidemiologists
- Describe some of the aspects of tick biology/ecology important for pathogen transmission
- Discuss tick control measures

TICK ECOLOGY FOR EPIDEMIOLOGISTS

December 15, 2015

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U.S. National Tick Collection



Among arthropod vectors of diseases ticks are only next to mosquitoes in terms of diversity of pathogens they can transmit (bacteria, viruses, protozoans)

At the attachments site, ticks can cause irritation and local infection of the skin

Allergic reactions at the bite site can be severe (meat allergy?)

Ticks can cause anemia in the host if attached in large quantities

Main diseases: Spotted fevers, Lyme disease and other borrelioses (relapsing fever), ehrlichioses, anaplasmoses, viral disease (Crimean-Congo hemorrhagic fever, tick-borne encephalitis, Colorado tick fever, babesiosis, theileriosis)

The main goals of the study of the eco-epidemiology of tick-borne diseases are:

understanding and describing transmission cycles

developing prevention strategies

In order to do so, one has to know ticks, their life cycle, their host and ecological preferences, their behavior, their biology

Ticks: what are they? Basic taxonomy

Tick morphology and its function

Tick life cycles

Tick behavior

How these aspects are involved in disease transmission

TICKS: WHAT ARE THEY?

Obligate, non-permanent, blood-feeding parasites of mammals, birds, reptiles, and amphibians

Found on every continent of the world



Ticks are MITES, NOT INSECTS!

TAXONOMY

Phylum Arthropoda

Subphylum Chelicerata

Class ARACHNIDA (spiders, scorpions, mites,

Subclass ACARI (= MITES)

Order Parasitiformes

Suborder Ixodida (TICKS)

Superfamily Ixodoidea (approx. 900 spp.)

Family

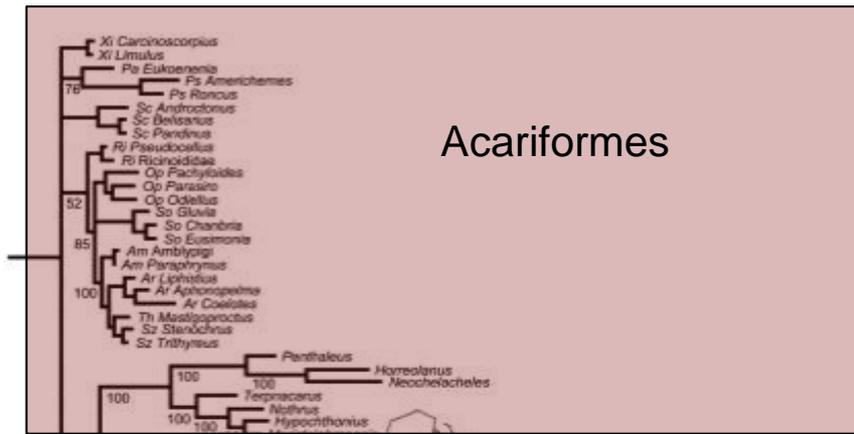
Ixodidae (hard ticks)
approx. 710 spp.

Family

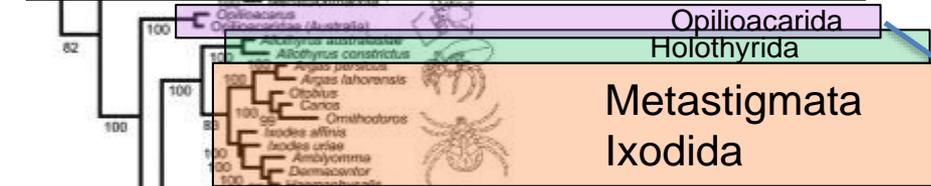
Nuttalliellidae
1. sp.

Family

Argasidae (soft ticks)
approx. 190 spp.



Relationships within Acari

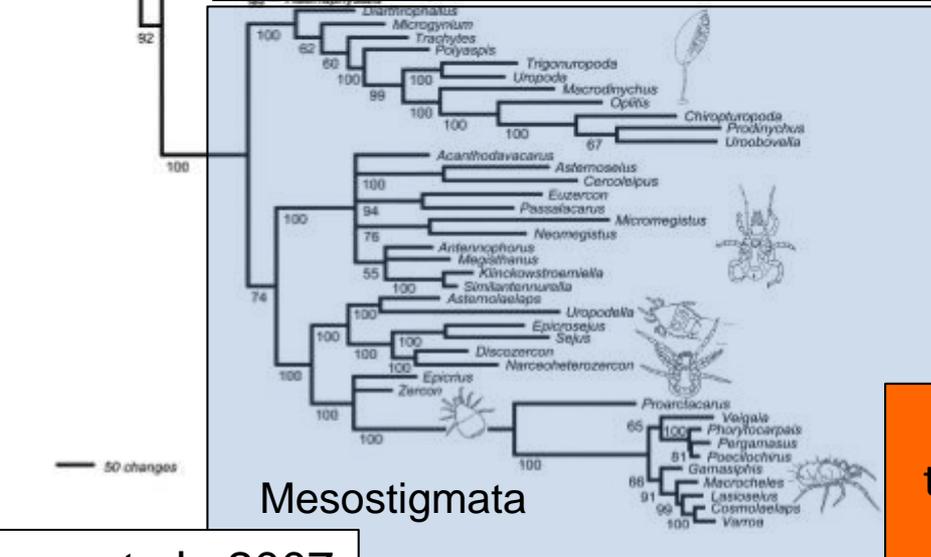


Opilioacarida

Holothyrida

Metastigmata

Ixodida



Mesostigmata

Parasitiformes

Klompen et al., 2007

Within Acari, closest relatives of ticks (Holothyrida) are not parasitic organisms!
 Holothyrids are scavengers that feed mostly on dead arthropods.

Family

Ixodidae (hard ticks)

approx. 713 spp. in 12 genera



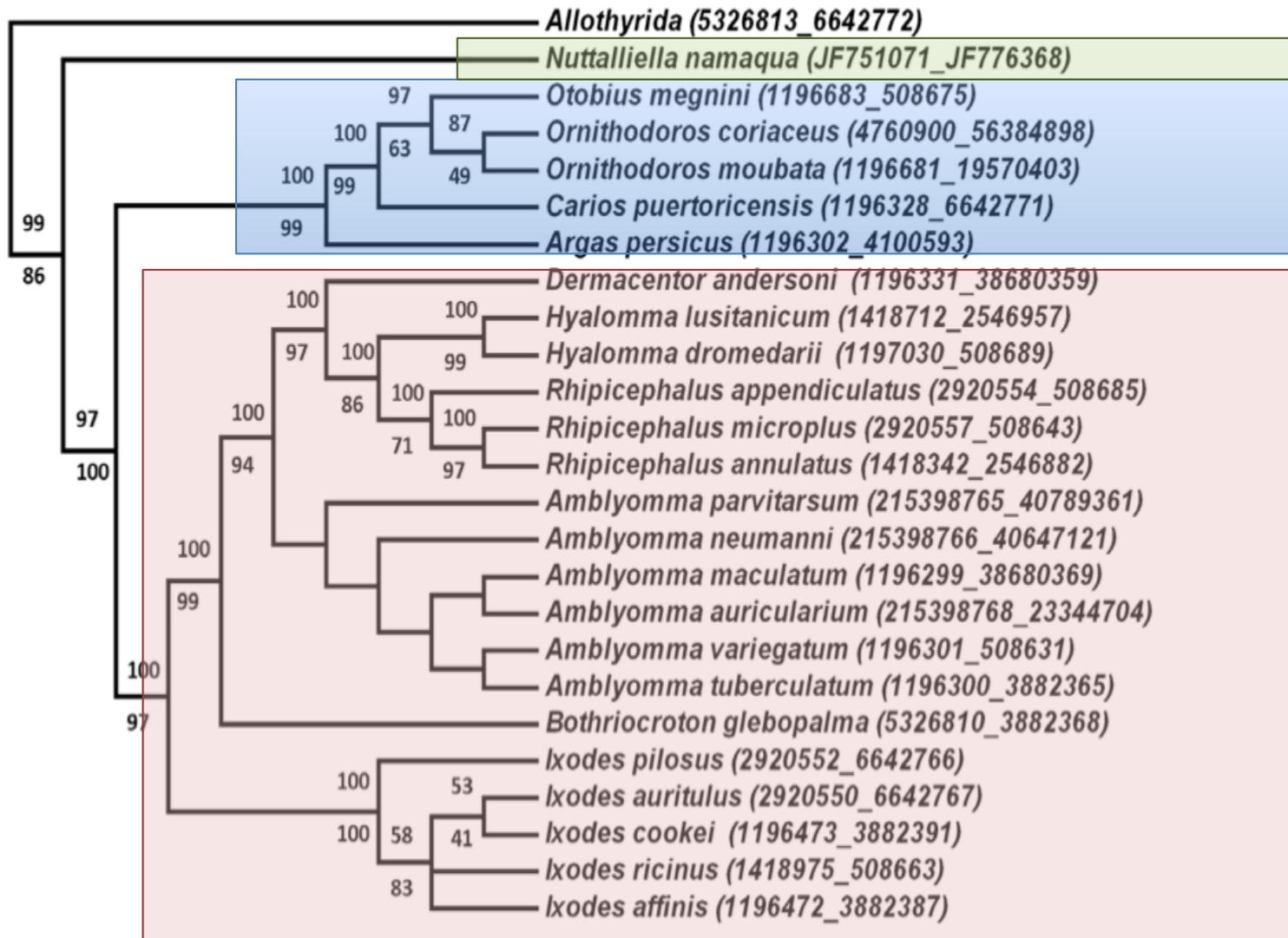
Family

Nuttalliellidae

1. sp. in 1 genus



Relationships among tick families



Mans et al., 2012

Family Ixodidae:

Sub families:

Ixodinae: genus *Ixodes*

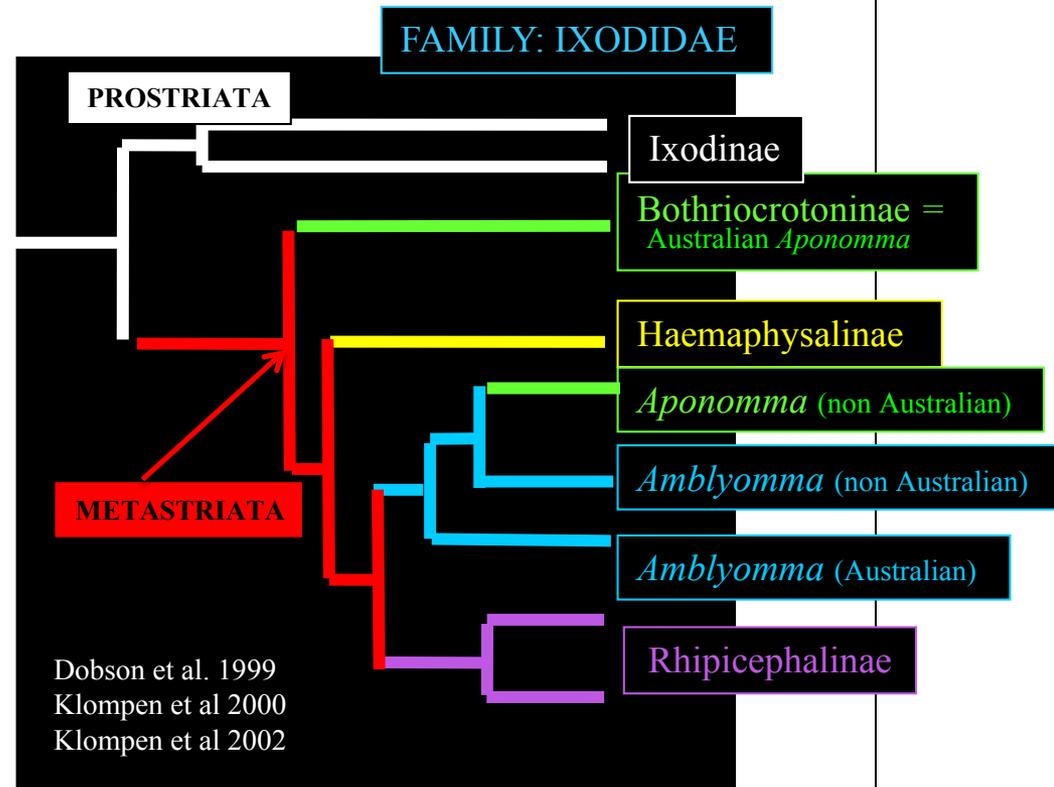
Bothriocrotoninae: genus *Bothriocroton*

Amblyomminae: genus *Amblyomma*

Haemaphysalinae: genus *Haemaphysalis*

Rhipicephalinae:

Rhipicephalus
Rhipicephalus (Boophilus)
Dermacentor
Anocentor
Hyalomma
Anomalohimalaya
Cosmiomma
Nosomma
Margaropus
Rhipicentor



Evolving field
Taxonomists never agree!

Why insist on taxonomy?

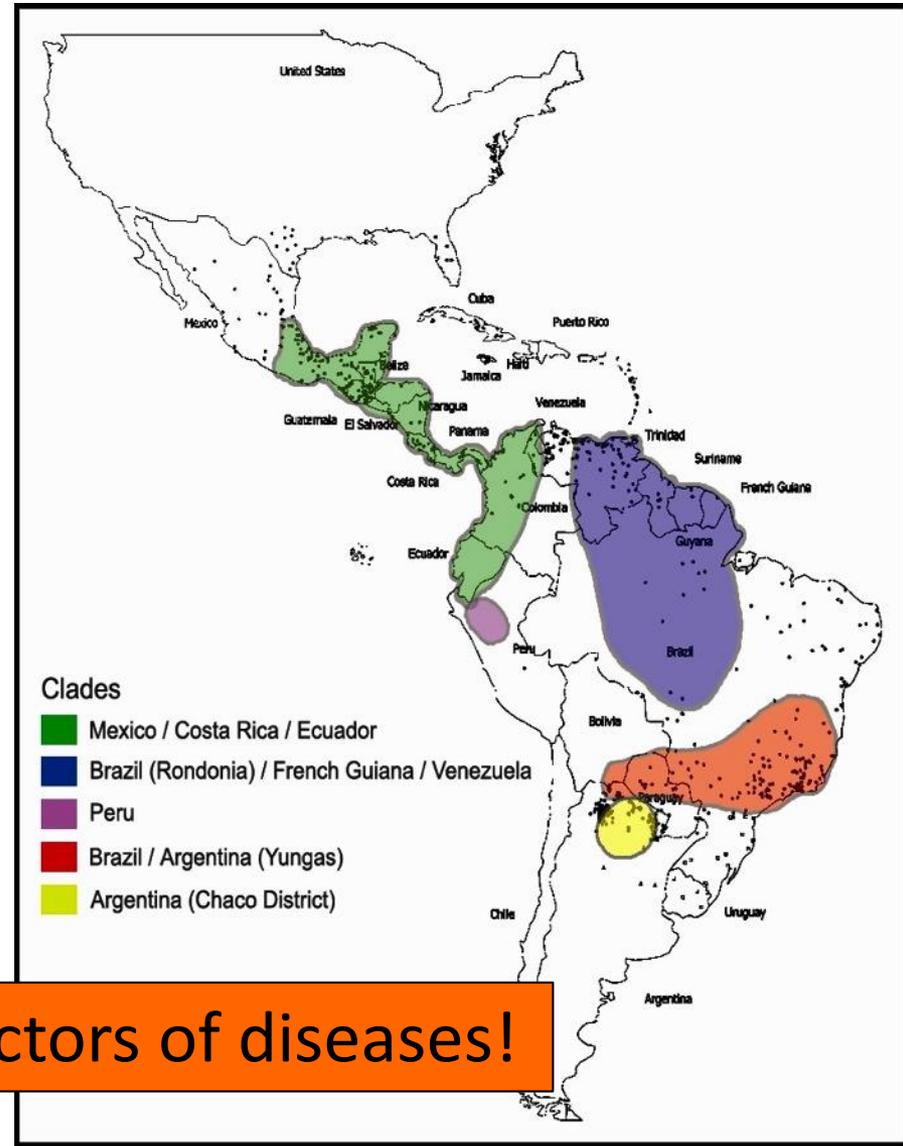
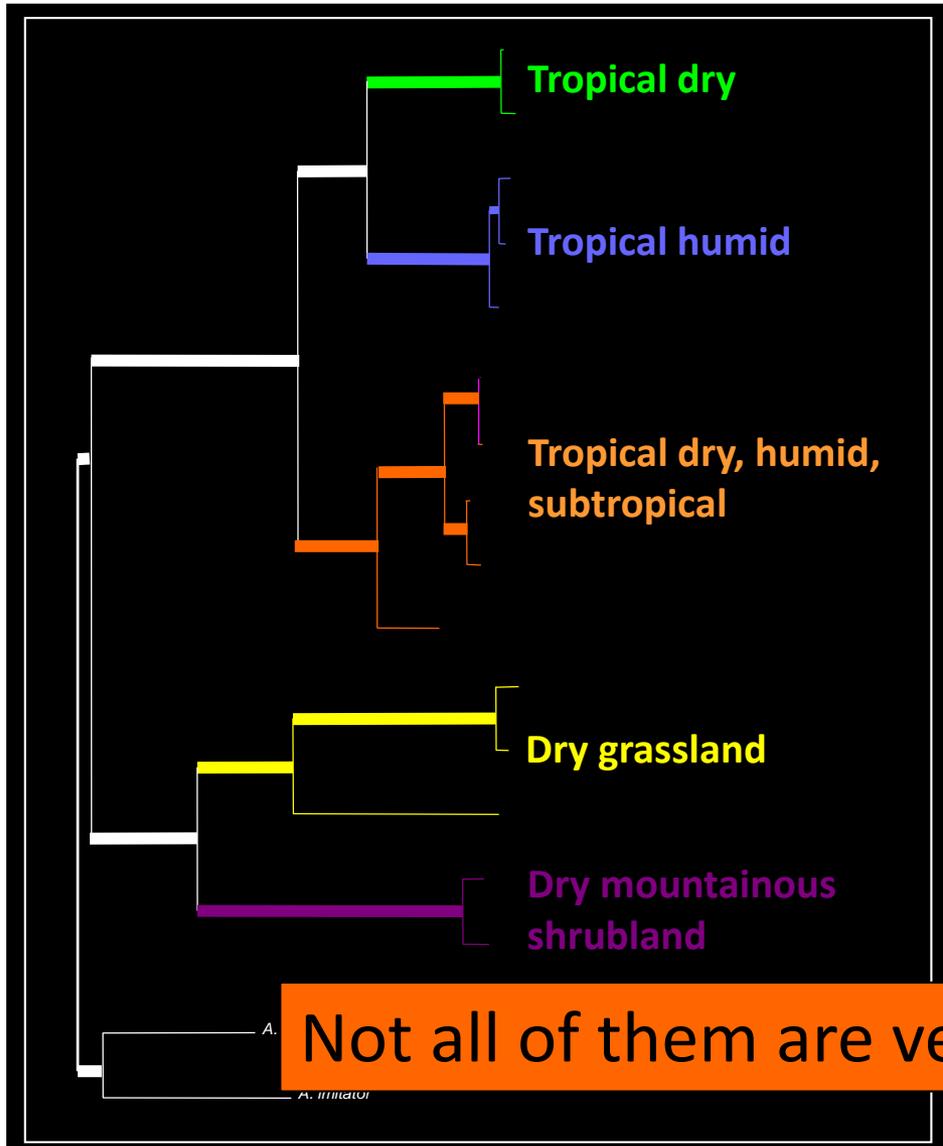
We need to be able to identify ticks in order to:

- understand tick life cycles
- characterize association with hosts (potential reservoirs of disease)
- describe associated habitat (geographic distribution, climatic and environmental preferences)

- understand eco-epidemiology of transmitted diseases
- elaborate appropriate and effective prevention strategies

Please, verify identifications, ask for help if necessary, deposit voucher specimens into recognized natural history collections when you do research and publish, do not destroy exoskeletons when you extract DNA!

A. cajennense = 6 different species



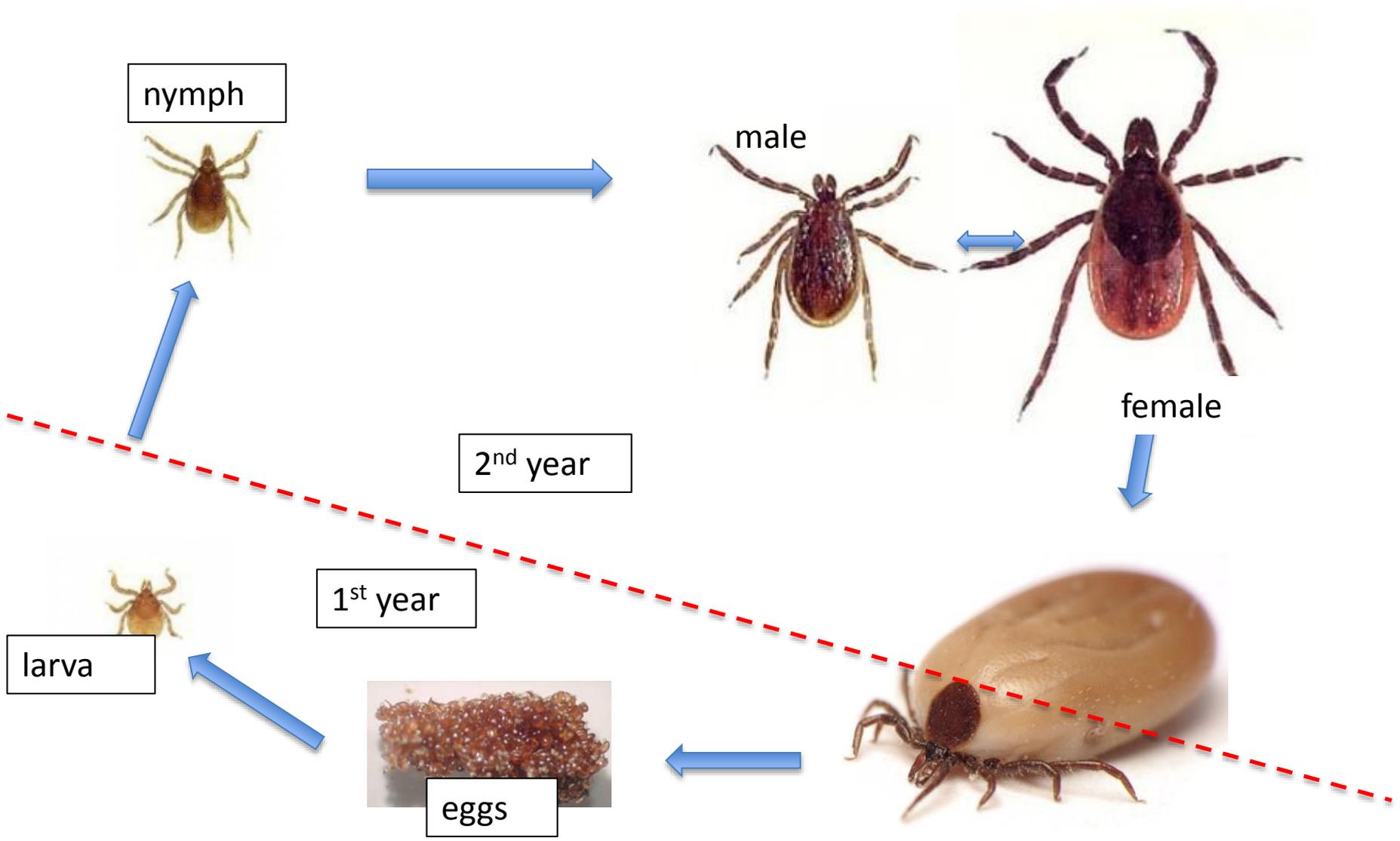
If you are interested in learning how to identify ticks:

Ohio State Acarology Summer Program

<https://acarology.osu.edu/>

Very basic pictorial key for adult hard-ticks of the eastern U.S.:

<http://us-tick-key.klacto.net/>



2-year life cycle of *Ixodes scapularis*

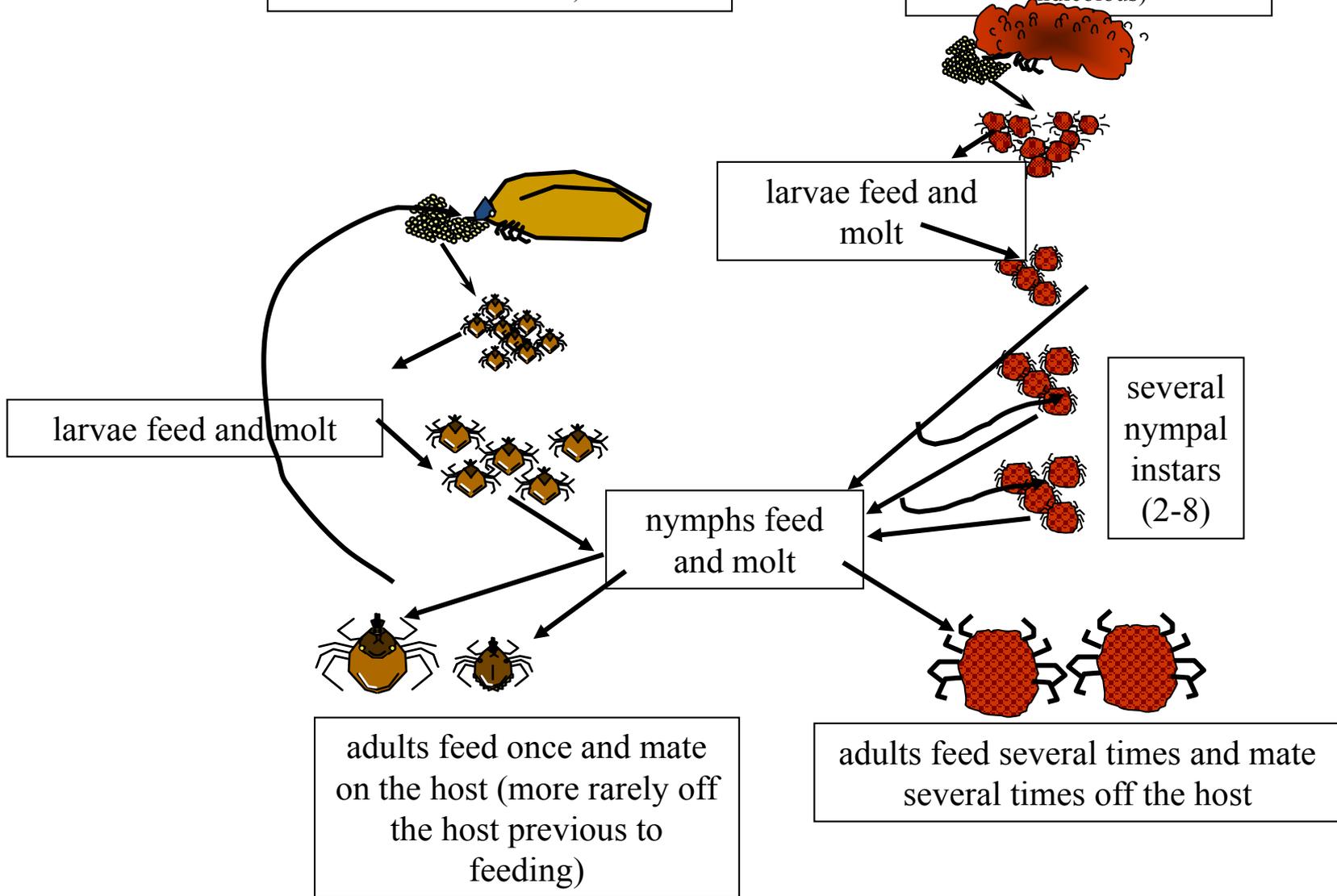
LIFE CYCLE (up to 2-3 years)

HARD TICKS

(long feeding periods, nidicolous and non-nidicolous)

SOFT TICKS

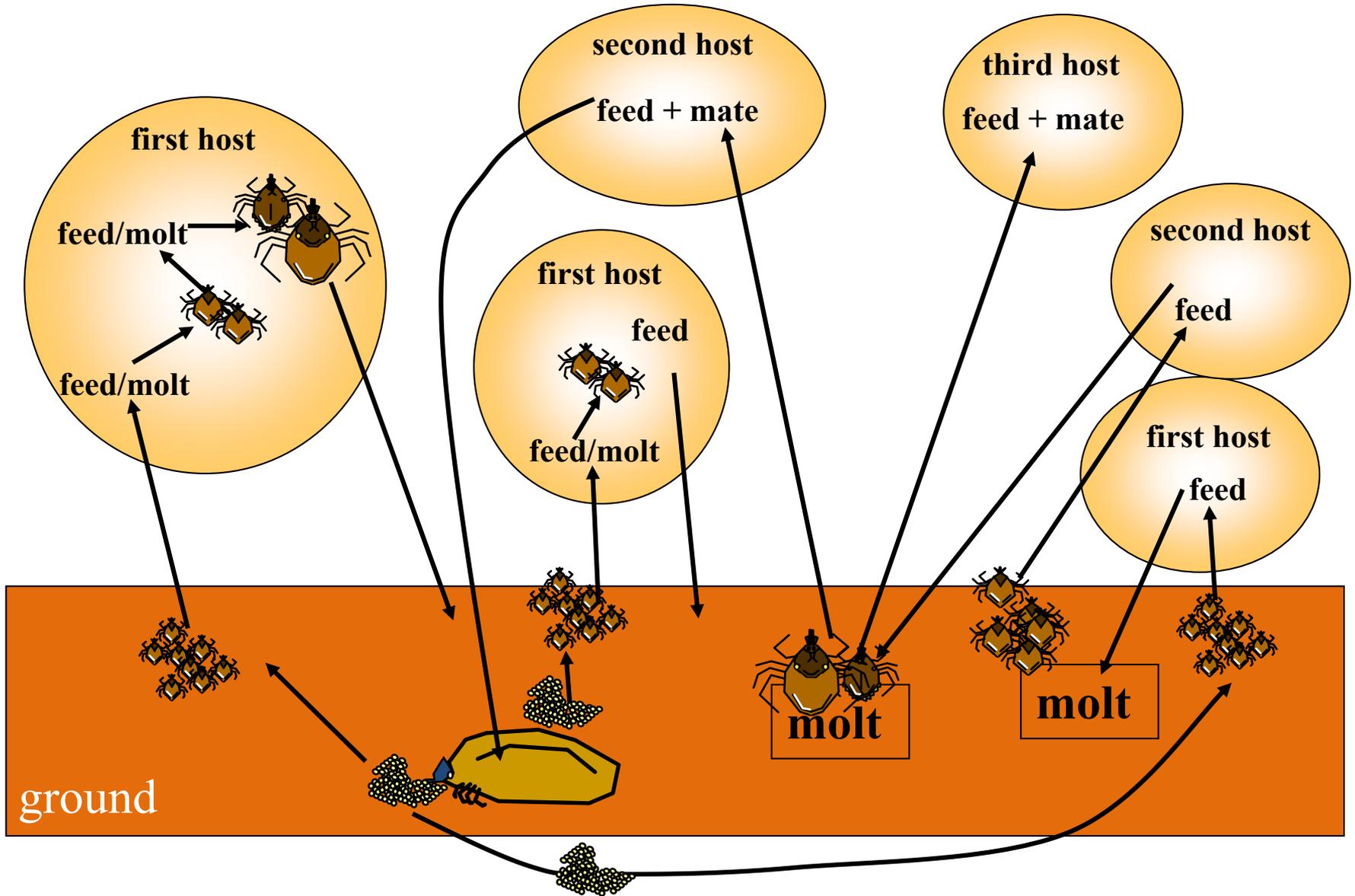
(brief feeding periods, mostly nidicolous)



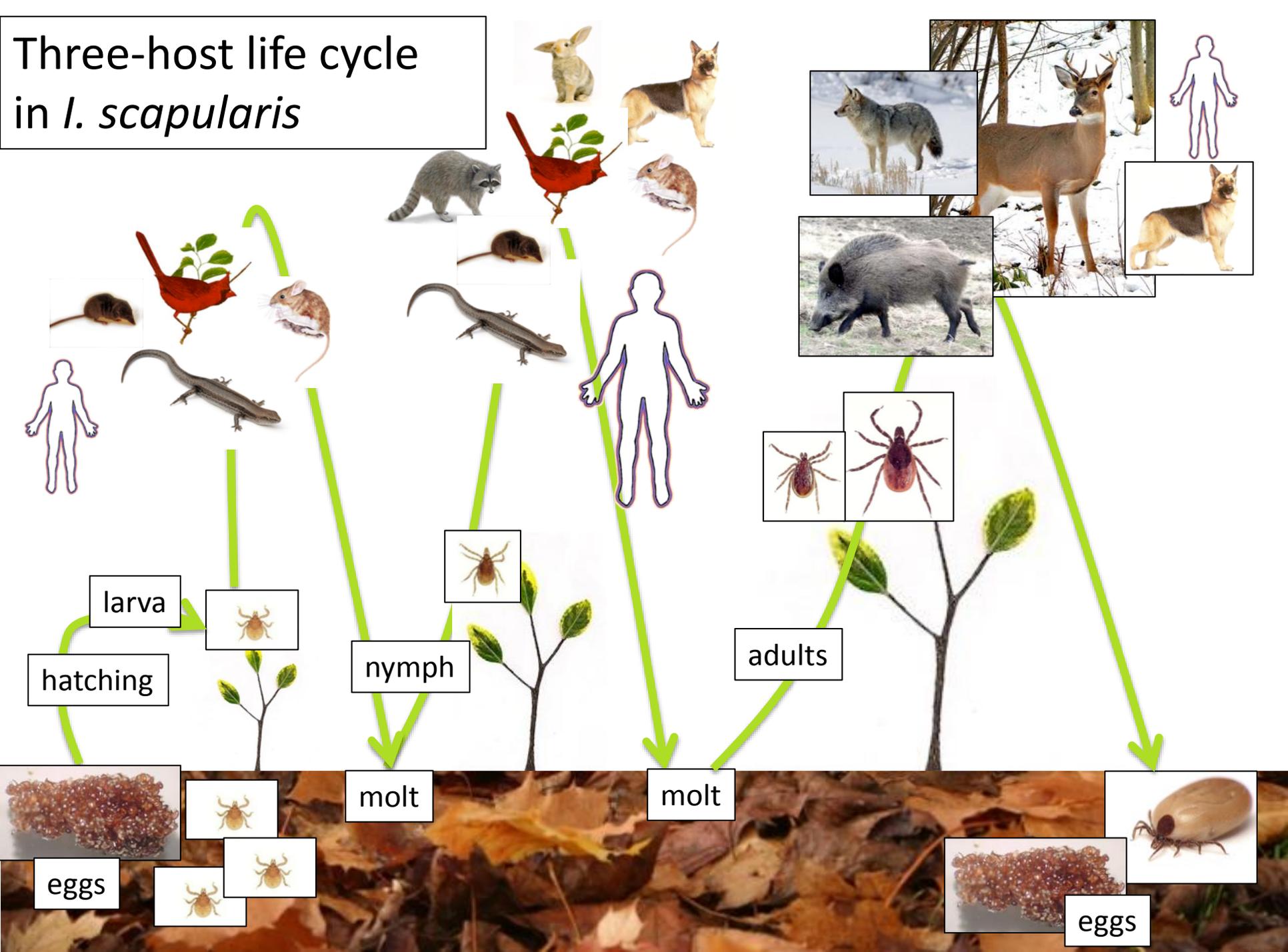
1-HOST CYCLE

2-HOST CYCLE

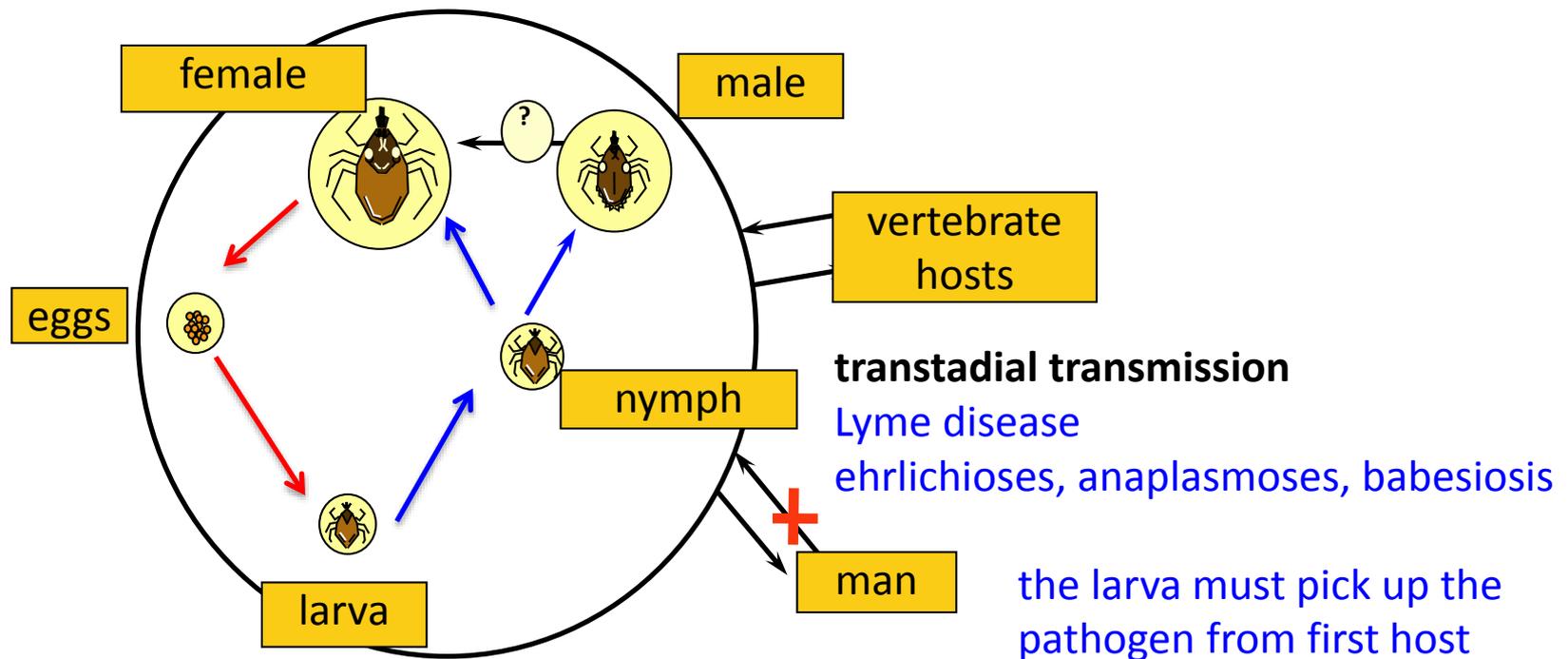
3-HOST CYCLE



Three-host life cycle in *I. scapularis*



Transovarial versus trans-stadial transmission of pathogens



transovarial transmission

SFG Rickettsia spp., some viruses,
Borrelia miyamotoi, relapsing fever
group spirochetes

The complement system of some animals
can “clear” *Borrelia* load inside ticks!

Host specificity? how important?

Good vectors of human diseases appear to be less host specific and non-nidiculous

Humans get involved “accidentally”

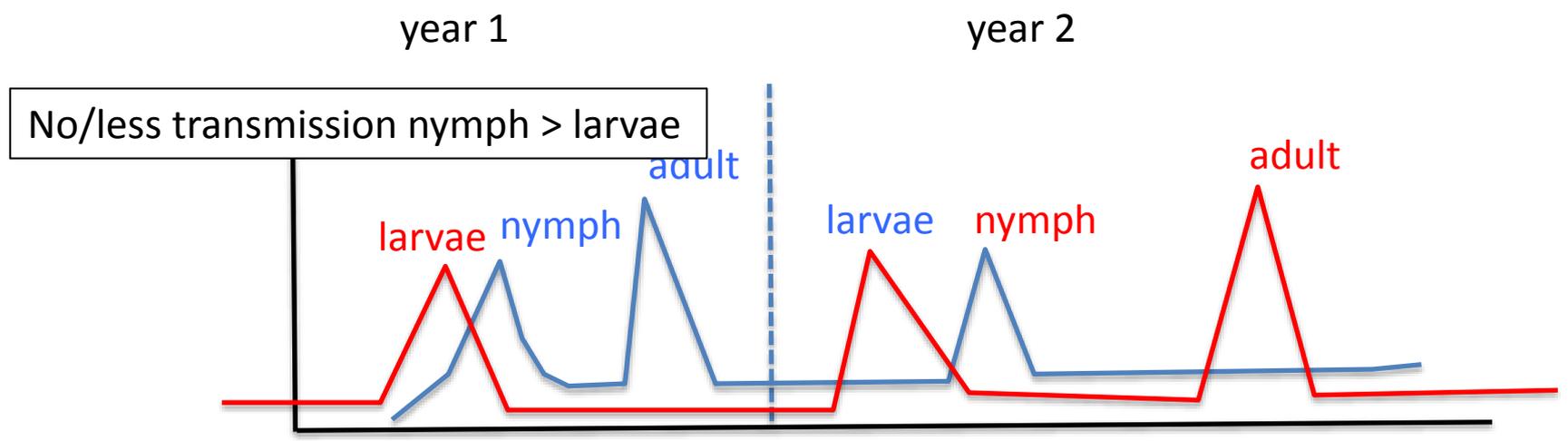
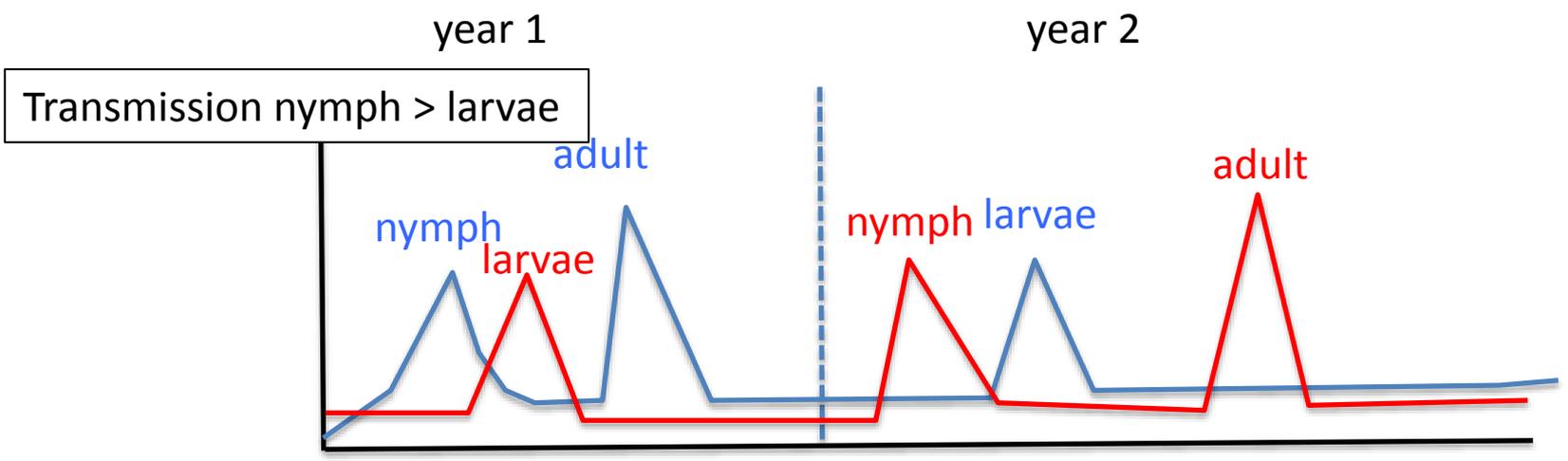
What about the environment?

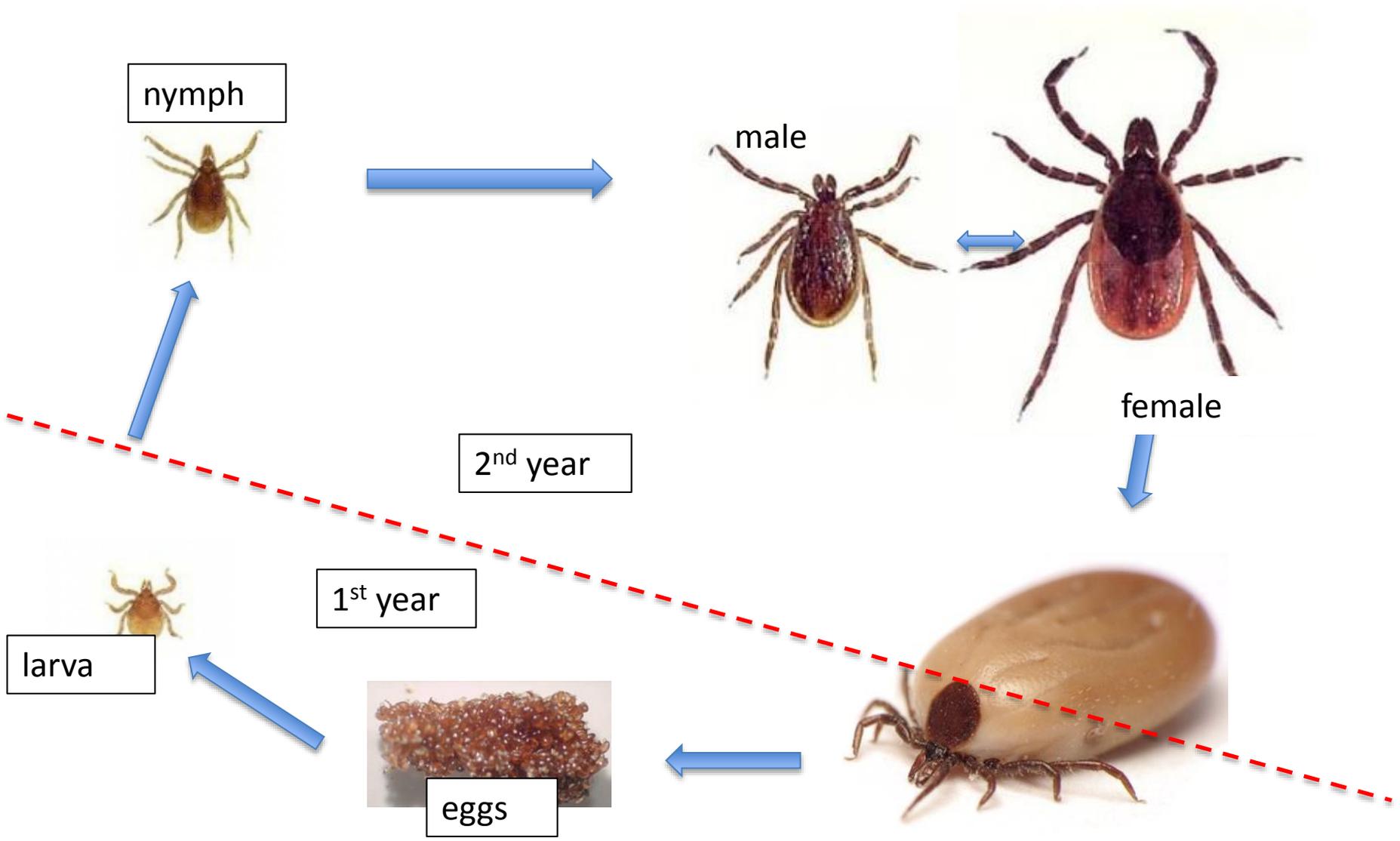
Ticks spend > 90% of their life off-host

Ticks live in preferred ecosystems, with very specific requirements in terms of climate, precipitations, vegetation cover, etc....

Ticks with wide geographical distribution may develop different seasonal activity cycles to adapt to different environmental conditions

Dynamics of seasonal activity peaks are important for trans-stadially transmitted pathogens



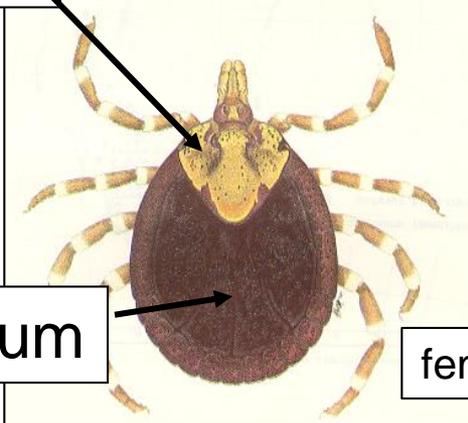


2-year life cycle of *I. scapularis*

scutum

Ixodidae

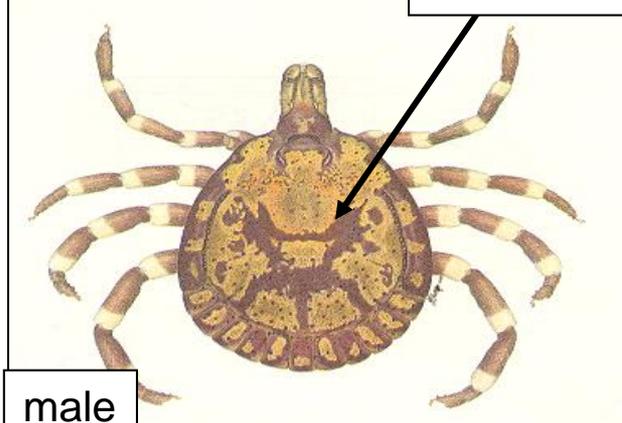
conscutum



alloscutum

female

Amblyomma sparsum



male

Argasidae



Argas walkerae



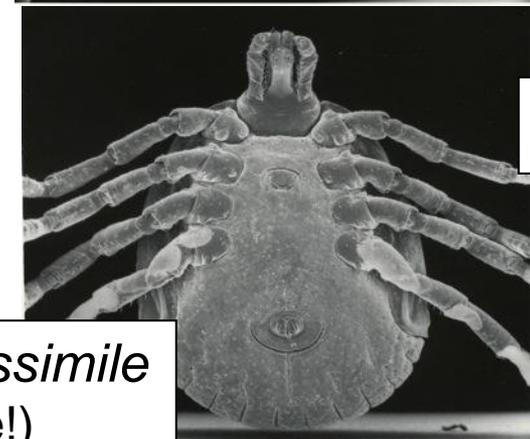
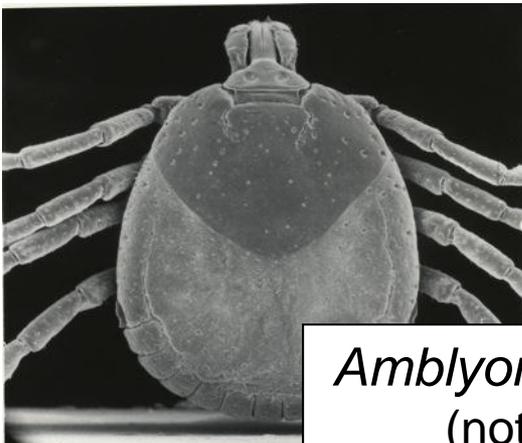
Ixodidae



larva
6 legs



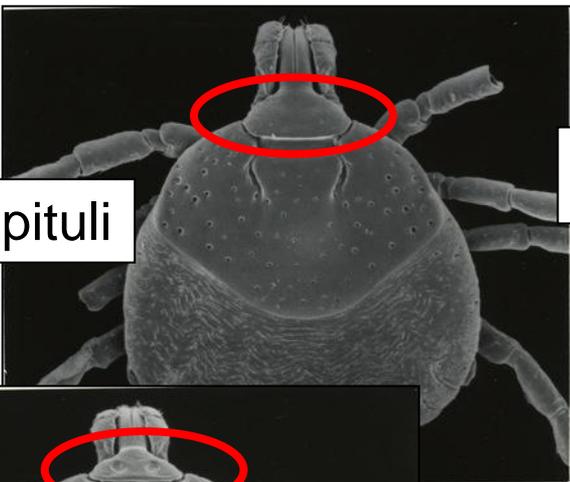
nymph



female

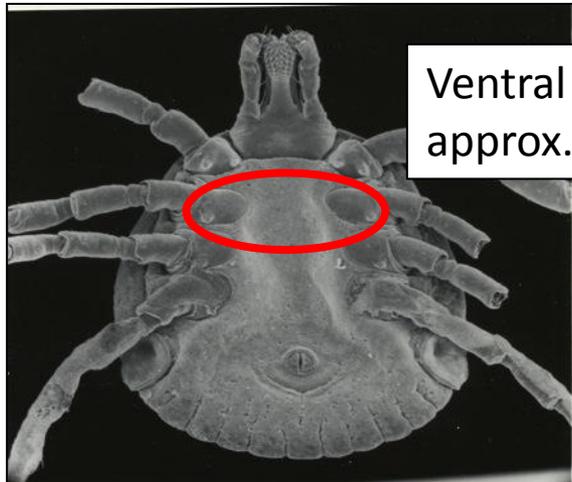
Amblyomma dissimile
(not to scale!)

Basis capituli

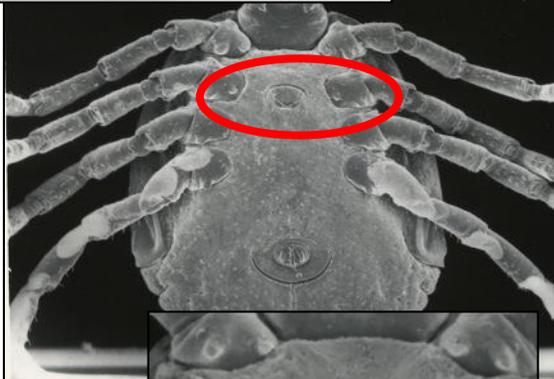
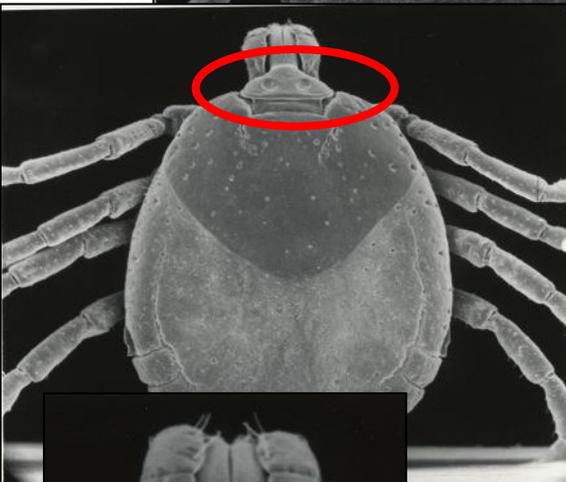


Nymph

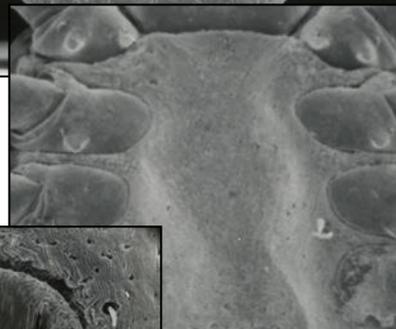
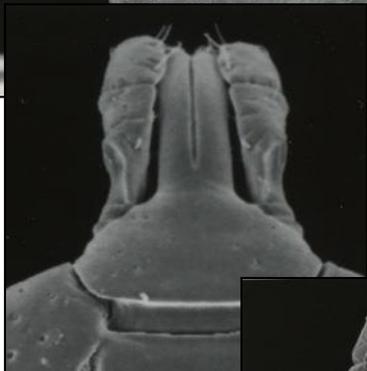
Ventral region
approx. leg II level



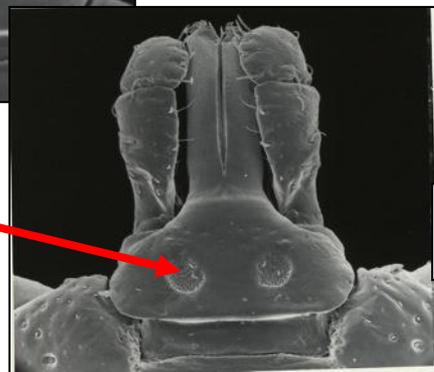
Female



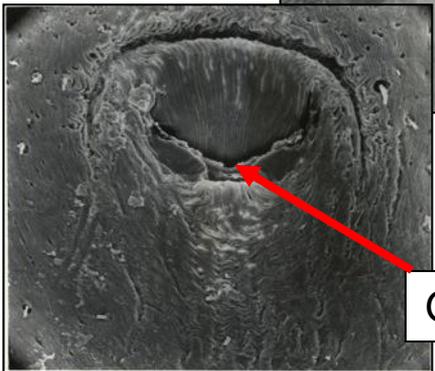
Nymph



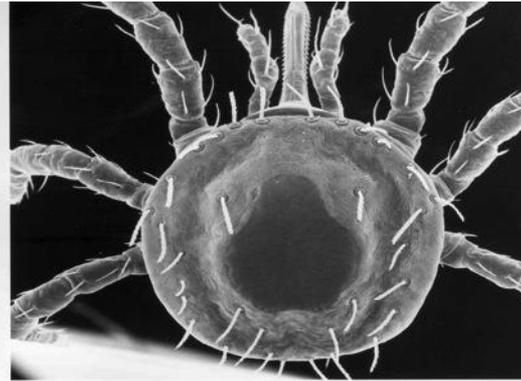
Porose areas



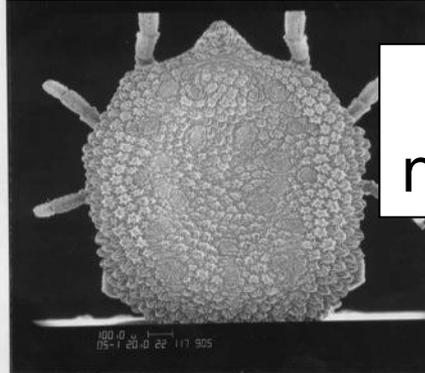
Female



Genital aperture



larva
6 legs



nymph
no genital aperture



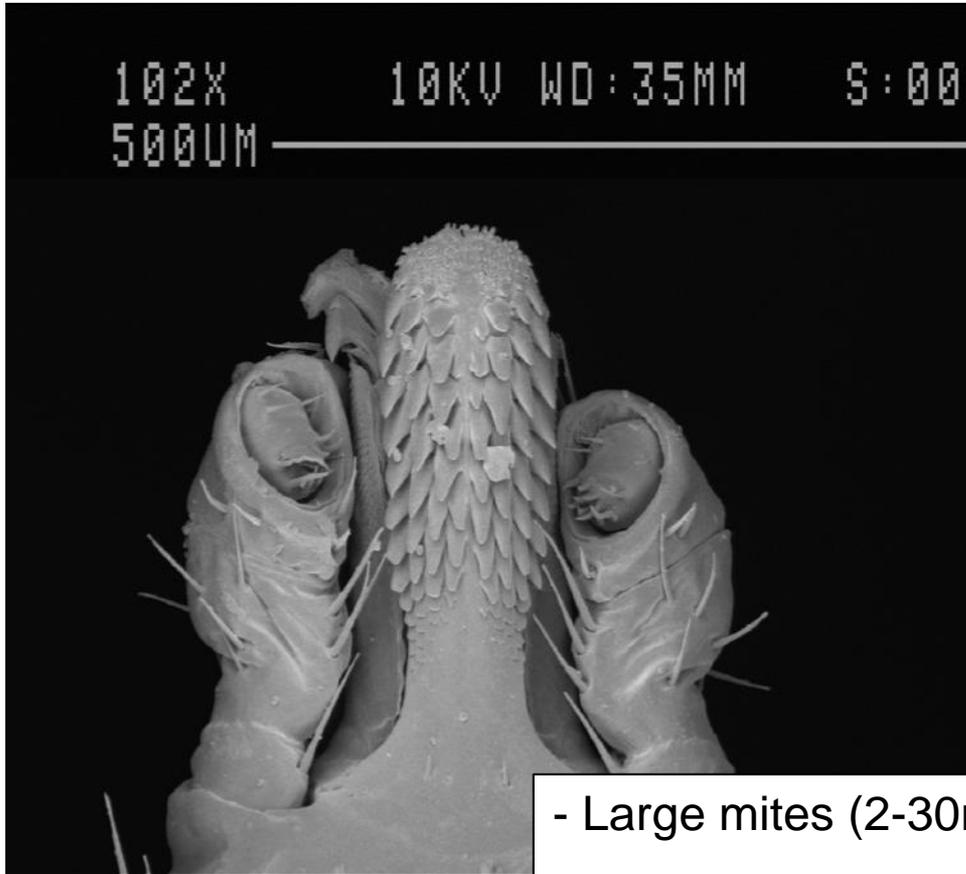
male



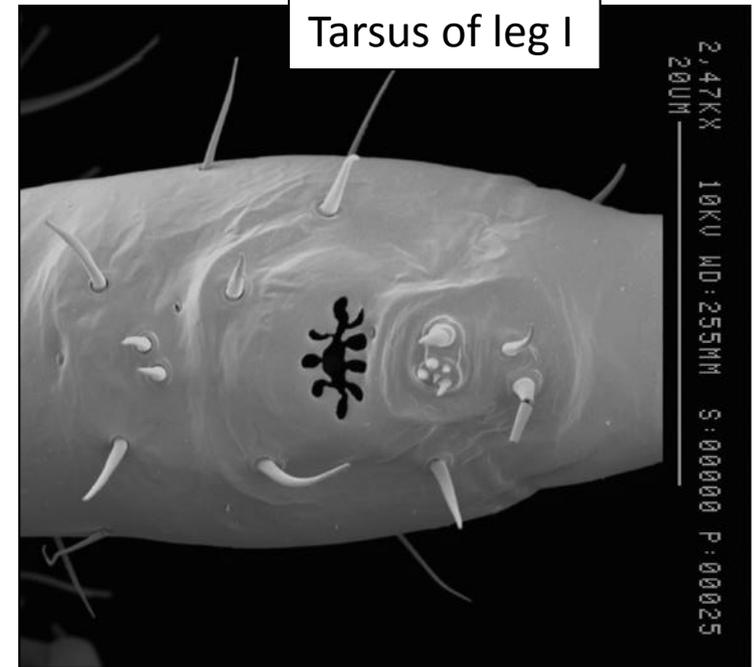
female

Argasidae - *Carios*

FEEDING AND QUESTING



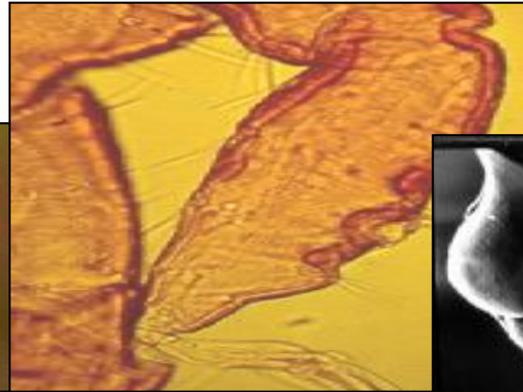
Ventral view of capitulum



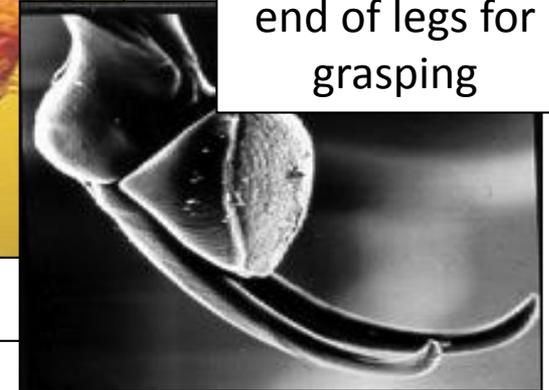
Tarsus of leg I

- Large mites (2-30mm)
- With specialized mouthparts (hypostome) with posteriorly directed denticles
- With specialized sensory structures on tarsus of leg I (Haller's organ)

Questing behavior



Haller's organ



Hooks at the end of legs for grasping

Do all ticks quest? NO

Some tick stalk rather than ambush their prey (some soft ticks, *Hyalomma* species, some *Amblyomma* species). To do so they use their eyes and follow chemical cues by using their sensorial receptors (Haller's organ)

Nidicolous ticks live in the nests/borrows of their preferred host
Protected from environmental variations, with constant source of food for as long as their habitat is occupied by the host

The brown dog tick, an example of a partially nidicolous tick (leaving inside houses, kennels, in peridomestic environments)

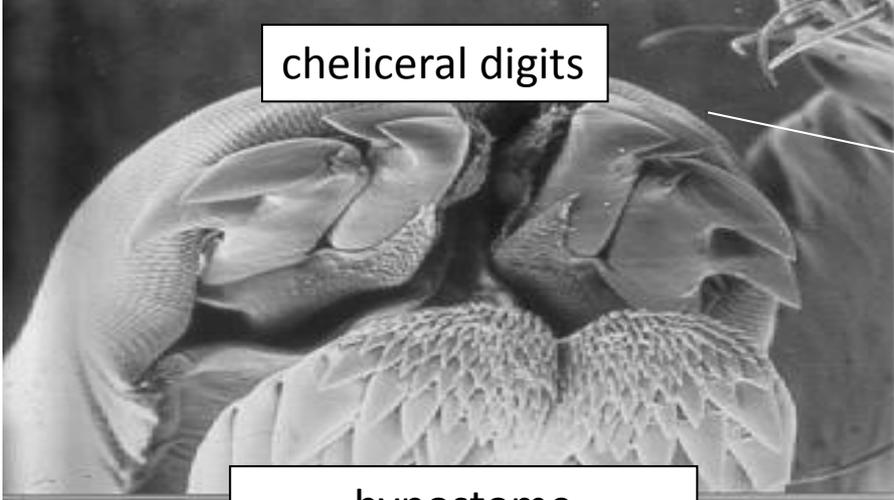
“Rhipicephalus sanguineus” – like ticks

Taxonomic issues that need to be solved

Vector of Rocky Mountain spotted fever



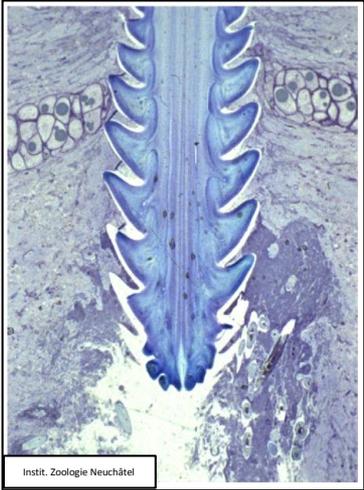
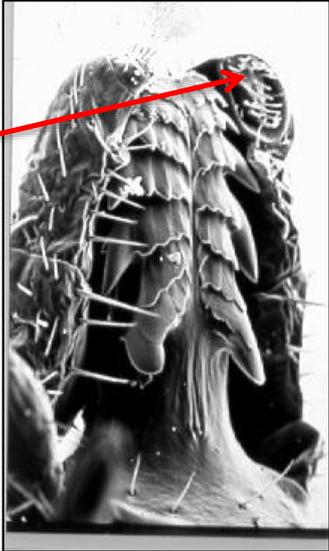
Feeding



cheliceral digits

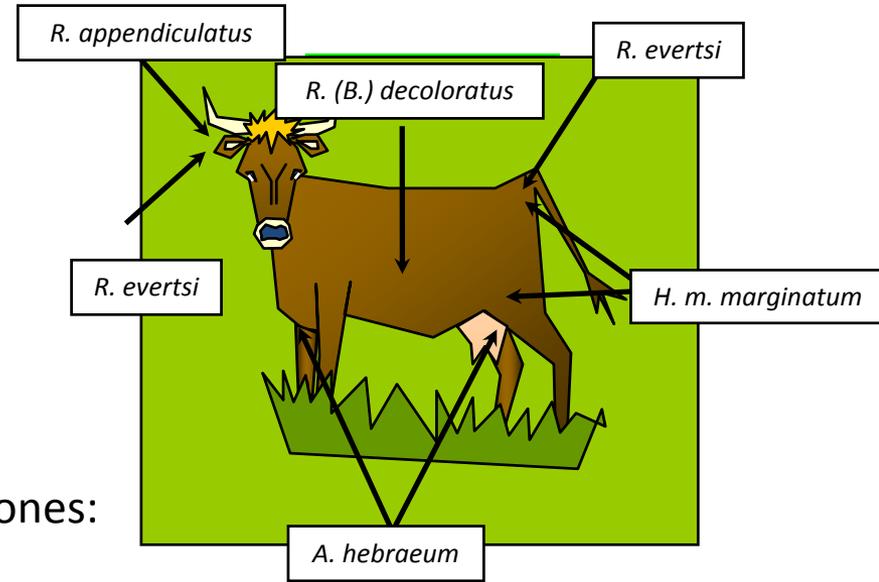
hypostome
with ventral denticles

segment IV of palps
(sensorial)



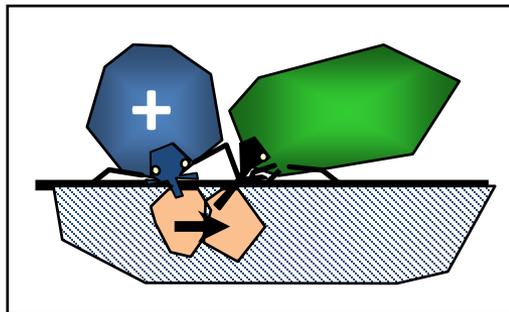
Hypostome of a tick
inside the host skin

The denticles of the
hypostome act like
harpoon barbs,
preventing the tick
from being removed
easily



Ticks cluster at the biting site attracted by pheromones:

- what's the benefit of feeding together?
- For adults: finding a mate because adult ticks feed and mate at the same time
- Avoid competing for food with other tick species that might cluster on other areas of an animal body
- what else?

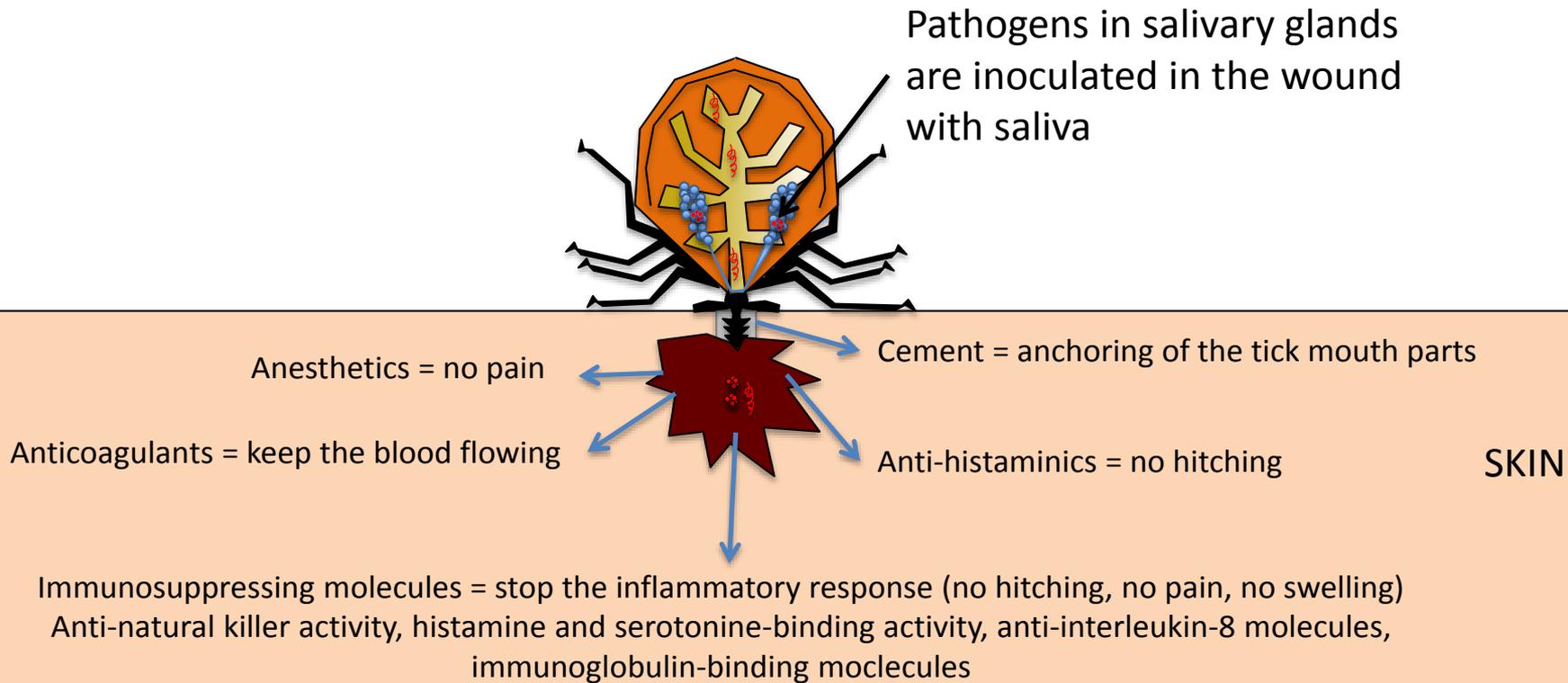


Co-feeding transmission of pathogens



WHY CAN TICKS TRANSMIT SO MANY DIFFERENT PATHOGENS? BECAUSE TICKS DO NOT SIMPLY INJECT PATHOGENS, BUT THEY FACILITATE INDIRECTLY PATHOGEN MULTIPLICATION AND DISPERSAL THROUGH LOCAL IMMUNOSUPPRESSION

Hard-ticks need to feed for a long time (up to 10 days) attached to the same spot on the skin. Therefore, they do not want to be detected or dislodged by the host. In order to prevent being detected, they anesthetize and immunosuppress the host locally. For a pathogen, being inoculated in an immunosuppressed area is an obvious advantage.



TICK CONTROL:

- control tick density in nature (?)
 - chemicals (?)
- control tick habitat around houses
 - control deer density (?)
- biological control (fungi, parasitic wasps, nematodes)

INTEGRATION NECESSARY!

Prevention and control:

- avoid wooded areas during tick season (?)
- wear light-colored clothing, tuck pants into socks (?), apply repellents (permethrin on cloth, DEET), body check after outdoor activities in tick-infested areas
- transmission of many pathogens may take several hours of attachment: remove quickly crawling and attached ticks (from yourself and from your pets).

Tick removal:

-disinfect skin around tick

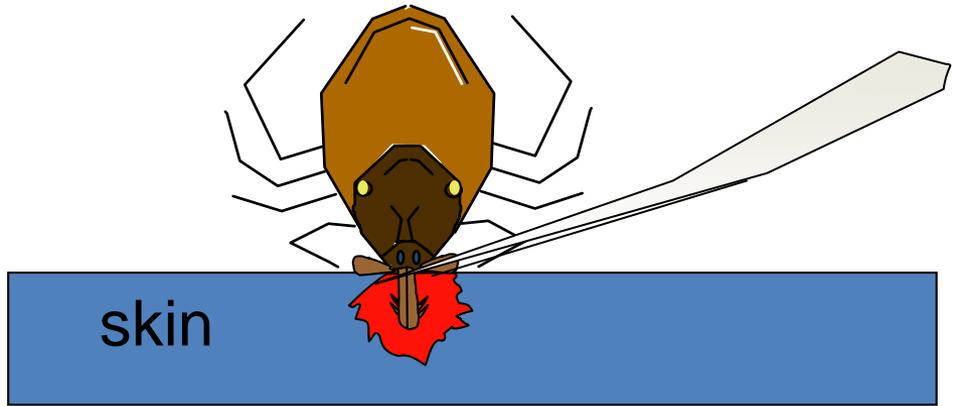
- adult, large ticks can be removed with fingers (hold ticks with tissue or gloves). Do not use fingers if skin abrasions, cuts present. Use fine-tipped tweezers for nymphs and larvae.

-Grasp tick as close to the skin as possible and pull straight out (rotation?), do not squeeze, crush, puncture the tick body

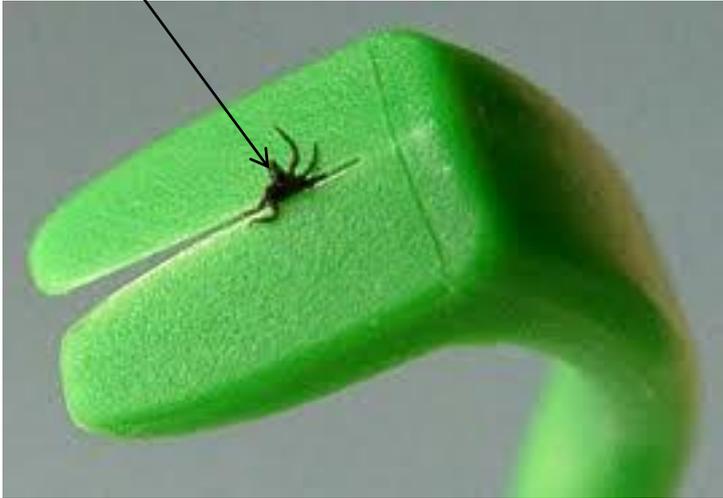
- Wash hands with soap after removing ticks.

- Disinfect skin again after tick removal

TICK REMOVAL:



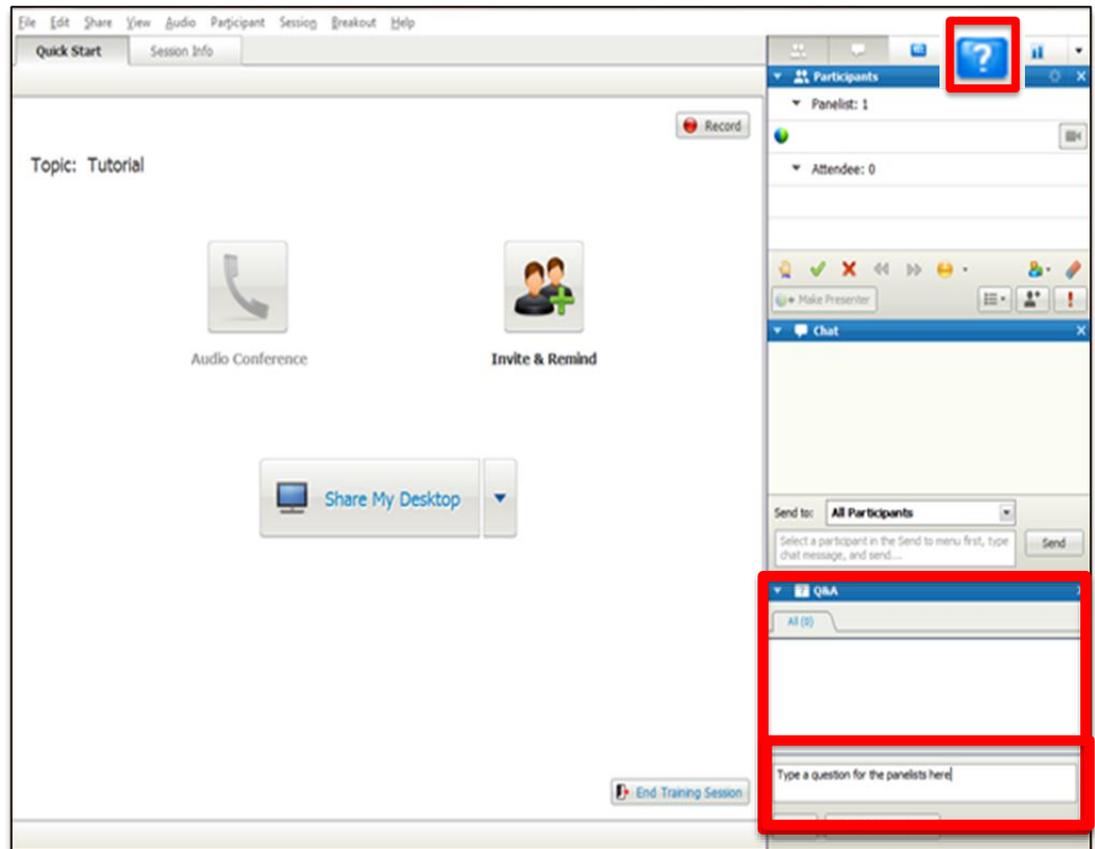
Bad example!!!!



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