BETWEEN FEATHERS AND FUR: THE HIDDEN LIVES OF HIPPOBOSCID FLIES AND OTHER ECTOPARASITES OF WILDLIFE CONCERN

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UNIVERSITY OF
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Arnold School of Public Health

OBJECTIVES

- **Ticks** (Acari: Ixodidae)
  - Life cycle
  - Local species of public health & veterinary importance
  - Surveillance initiatives in South Carolina- **and why we need your help!**
- **Deer keds** (Diptera: Hippoboscidae)
  - Life cycle
  - Host
  - Disease transmission
- **Sheep keds** (Diptera: Hippoboscidae)
  - Life cycle
  - Hosts
  - Disease transmission
- **Louse flies** (Diptera: Hippoboscidae)
  - Life cycle
  - Surveillance efforts in SC/NC
  - Disease Transmission
  - Microbiome
  - Future goals

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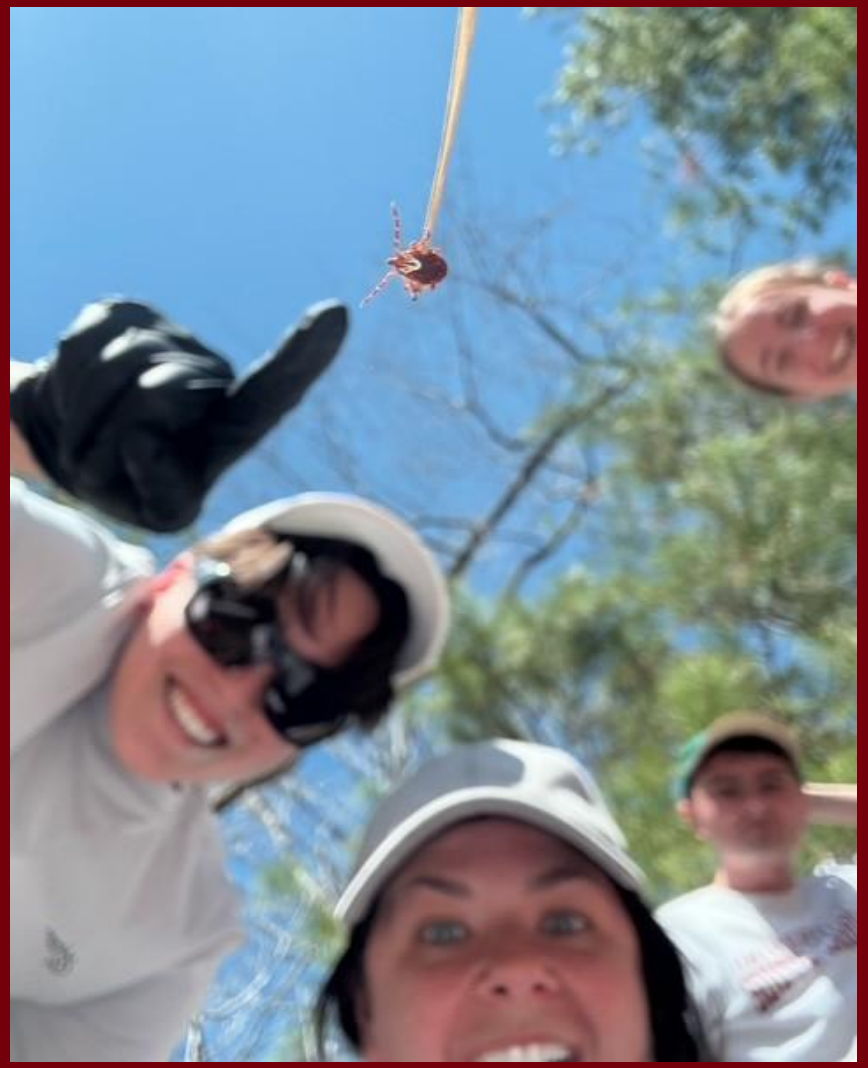
TICK SURVEILLANCE



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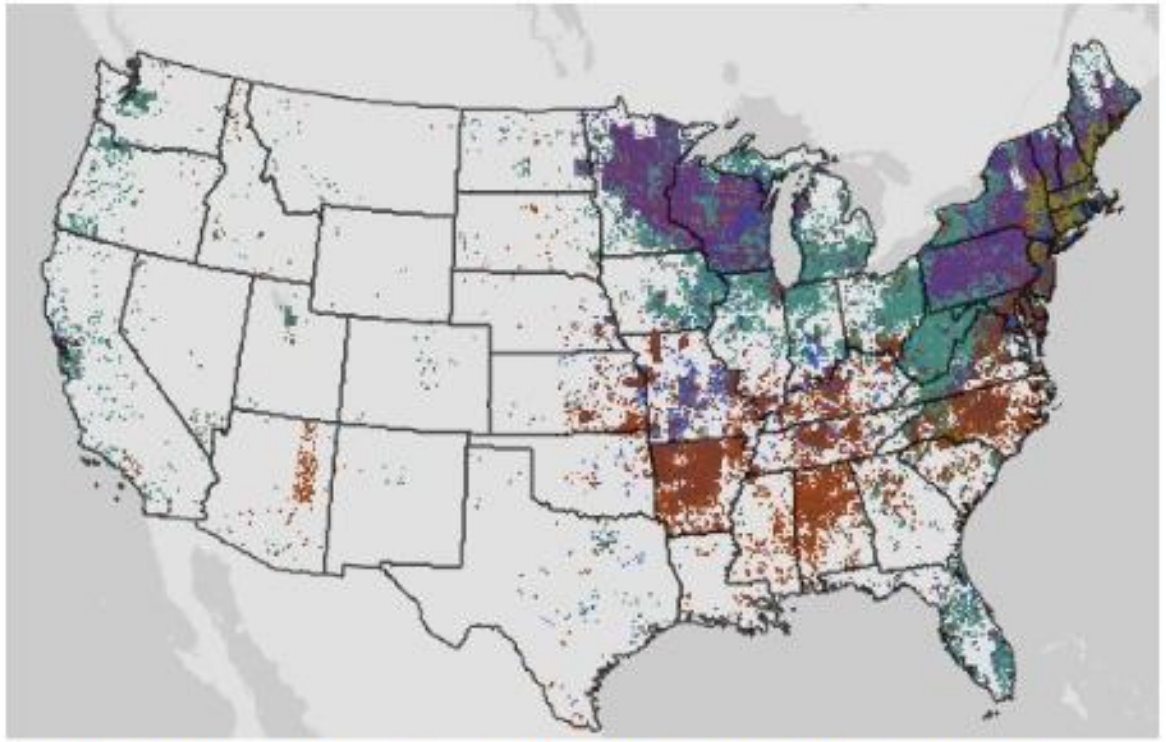
TICK-BORNE DISEASE PREVALENCE



Dot density map of total Reported Cases of Selected Tickborne Diseases from 2019 – 2022 by County of Residence, United States (CDC, 2023b). Each color dot represents a different reported TBD.

- In the past decade:
  - Tick-borne disease (TBD) incidence has tripled
  - Seven novel tick transmitted pathogens have been discovered nationally

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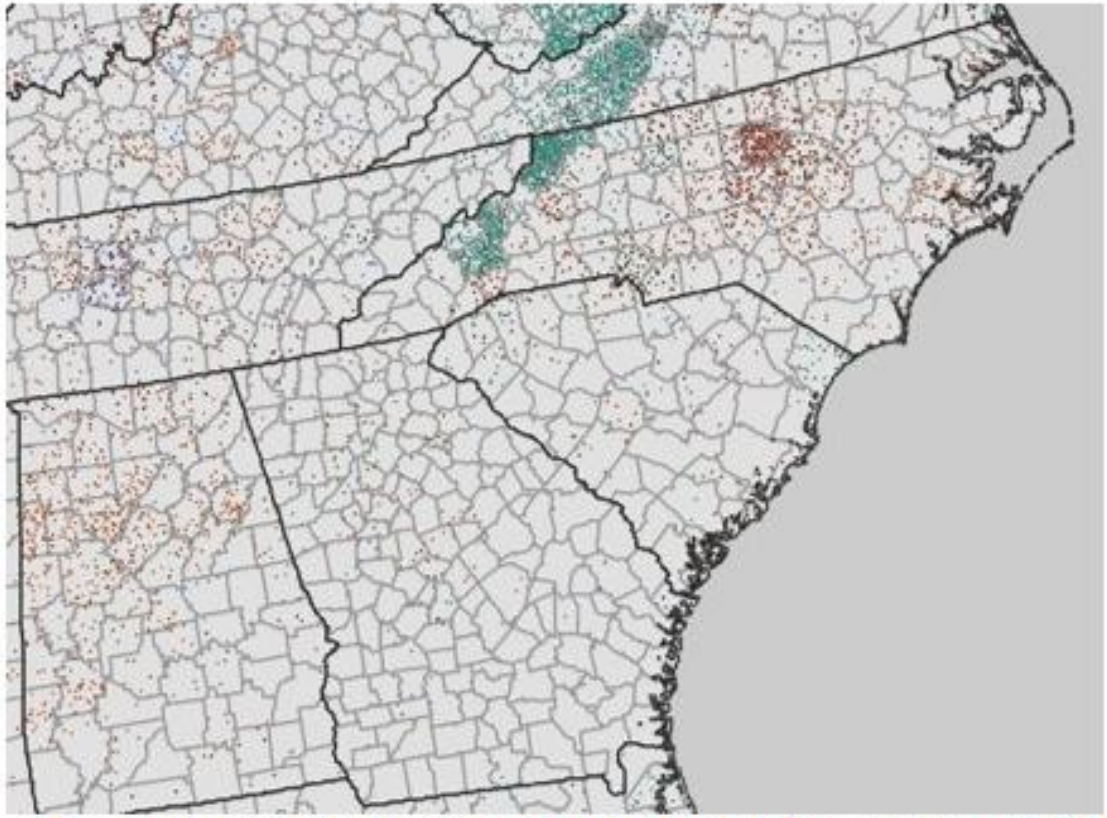
TBD BURDEN IN SC

- South Carolina (SC) is surrounded by high burden states and shares similar environmental landscapes.
- Between 2019 and 2022:
  - SC was only responsible for about 2.5% of all CDC reported TBD cases nationally.
  - Neighboring states (NC and GA) were responsible for up to 20.5%.



Dot density map of total Reported Cases of Selected Tickborne Diseases in South Carolina and neighboring states from 2019 – 2022 by County of Residence, (CDC, 2023b).

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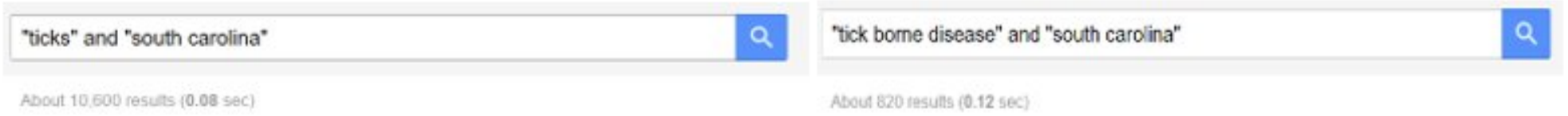
BUT WHY?

- Overall, there is a lack of published data on the prevalence of TBD in SC.



- This combined with a variety of different factors have contributed to the underreporting of TBDs.
- Most importantly however, SC historically has always had very limited surveillance systems.

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THE ROLE OF USC'S ZOONOTIC AND INFECTIOUS DISEASE LAB

1990

Georgia established their first statewide tick surveillance program.

1991

North Carolina established their first statewide tick surveillance program.

2020

South Carolina established their first statewide tick surveillance program.

2022

South Carolina expanded their surveillance efforts to also include public submissions.

2025

Today, South Carolina is partnered with 50 different animal shelters and 60 state and county parks across the state.

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KEY TICK SPECIES IN SC

The Lone Star Tick

- Most common tick in South Carolina
- Aggressive human biting tick
- Vector to a wide variety of pathogens

The Blacklegged Tick

- Less common than the Lone Star Tick, but still commonly found in our state parks

The Gulf Coast Tick

- Most common in Animal Shelter and Kennel Environments
- Common vectors for *Rickettsia parkeri*

The American Dog Tick and the Brown Dog Tick

- Most common in Animal Shelters and Kennel Environments

The Longhorned Tick

- Newer tick species
- Reproduce asexually
- Big impact on livestock

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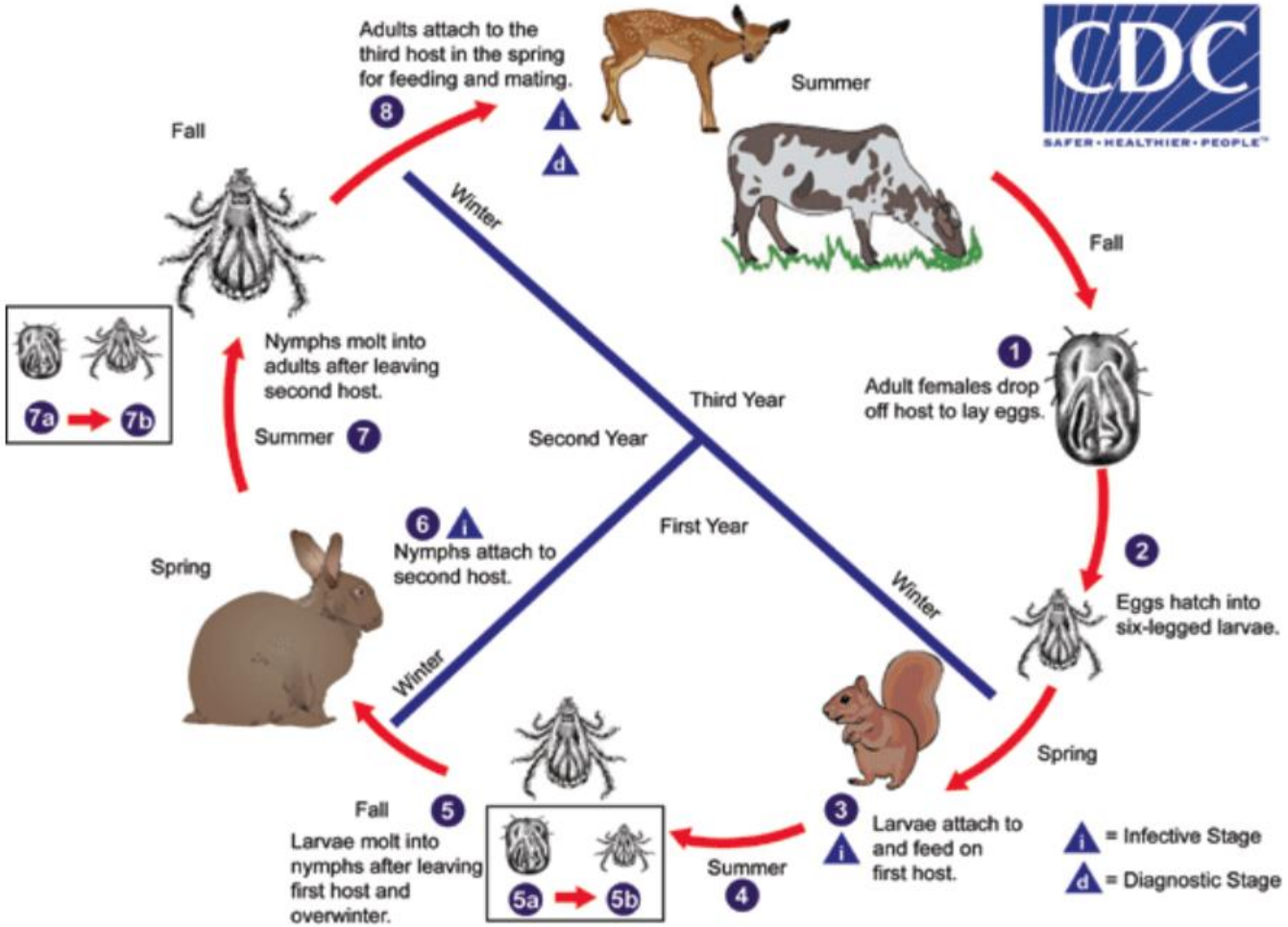
THREE-HOST TICK LIFECYCLE



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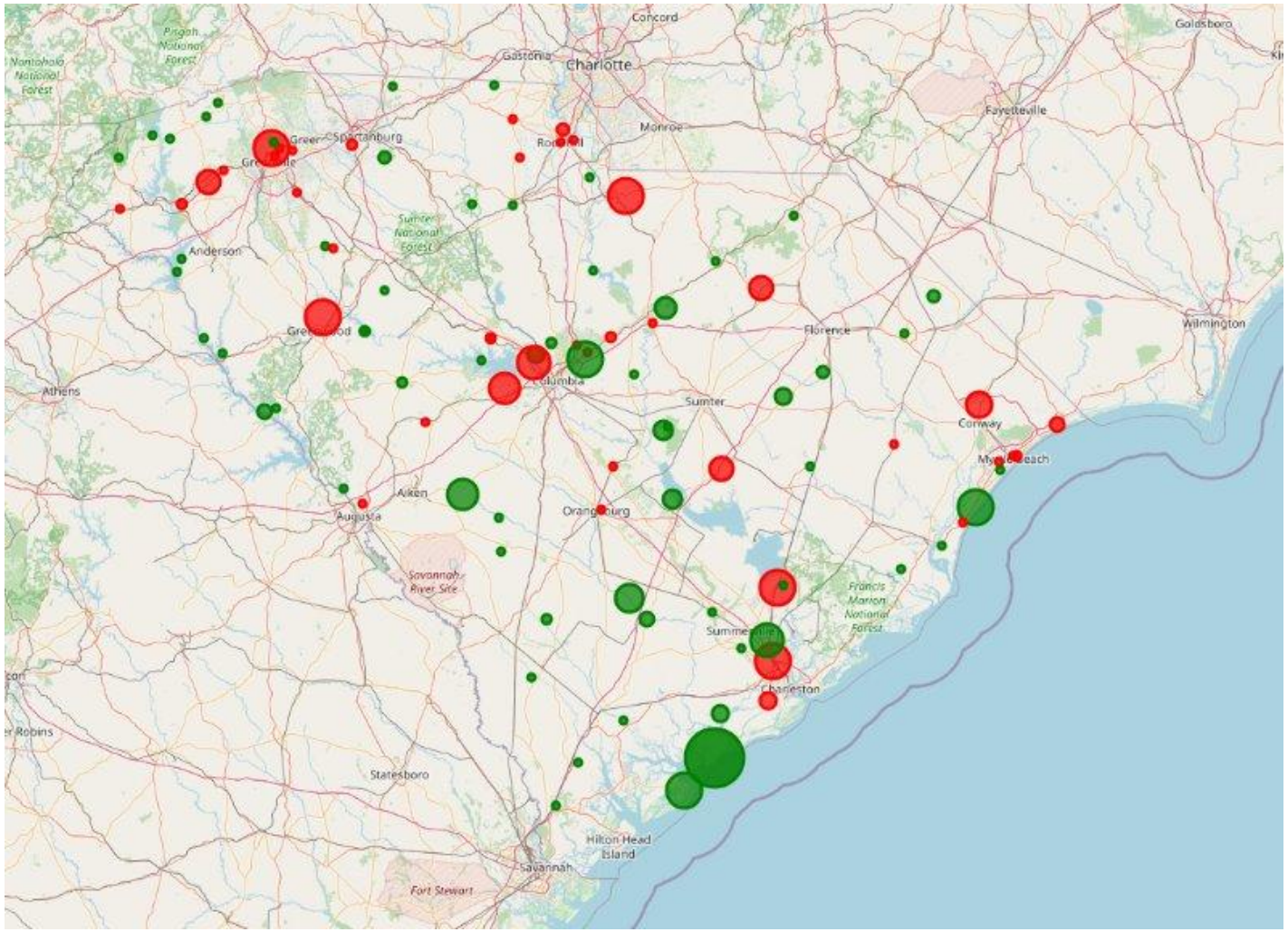
GEOGRAPHIC DISTRIBUTION



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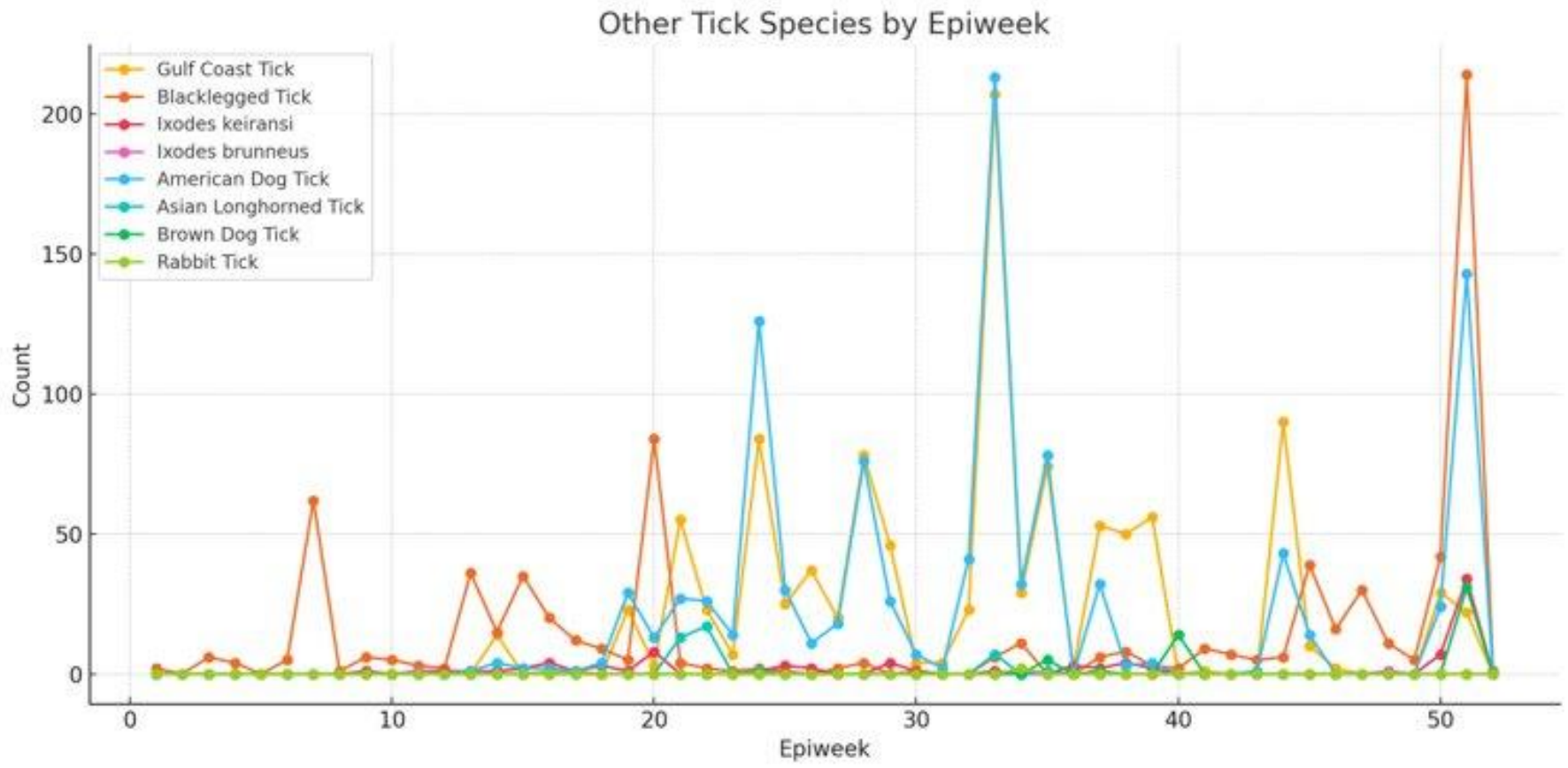
SEASONAL ACTIVITY PATTERNS



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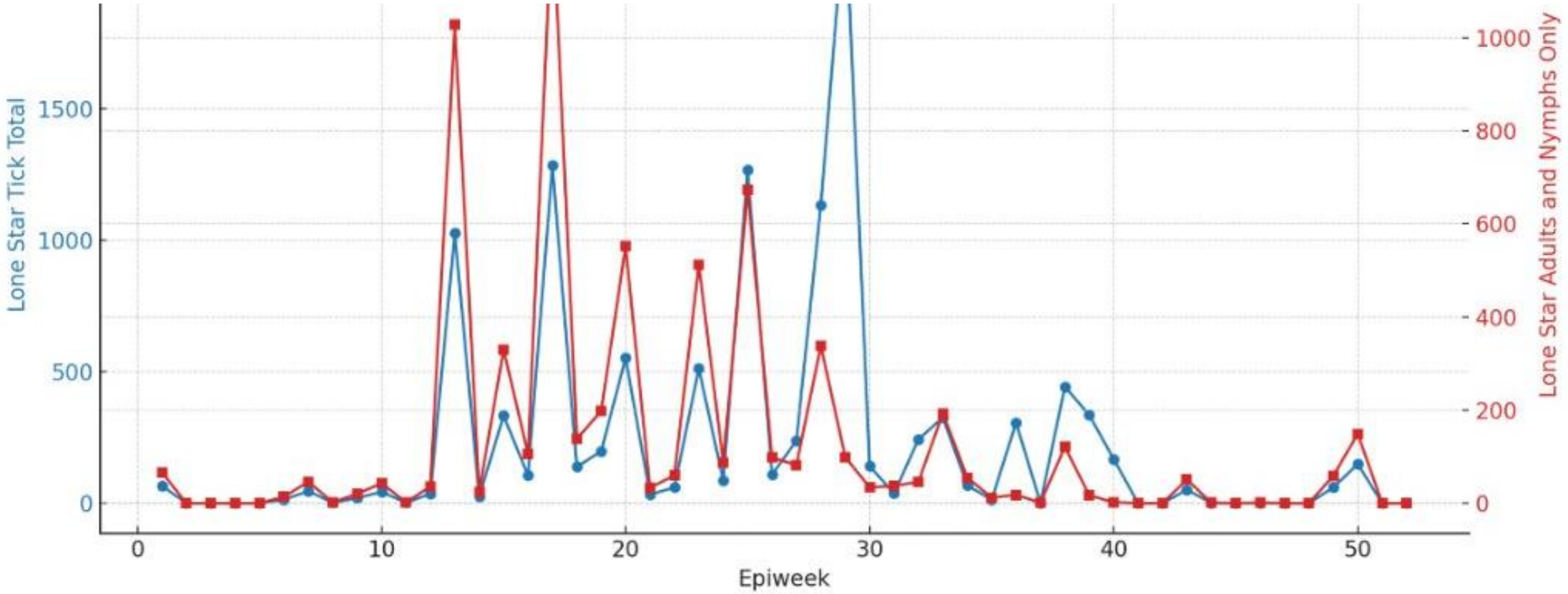

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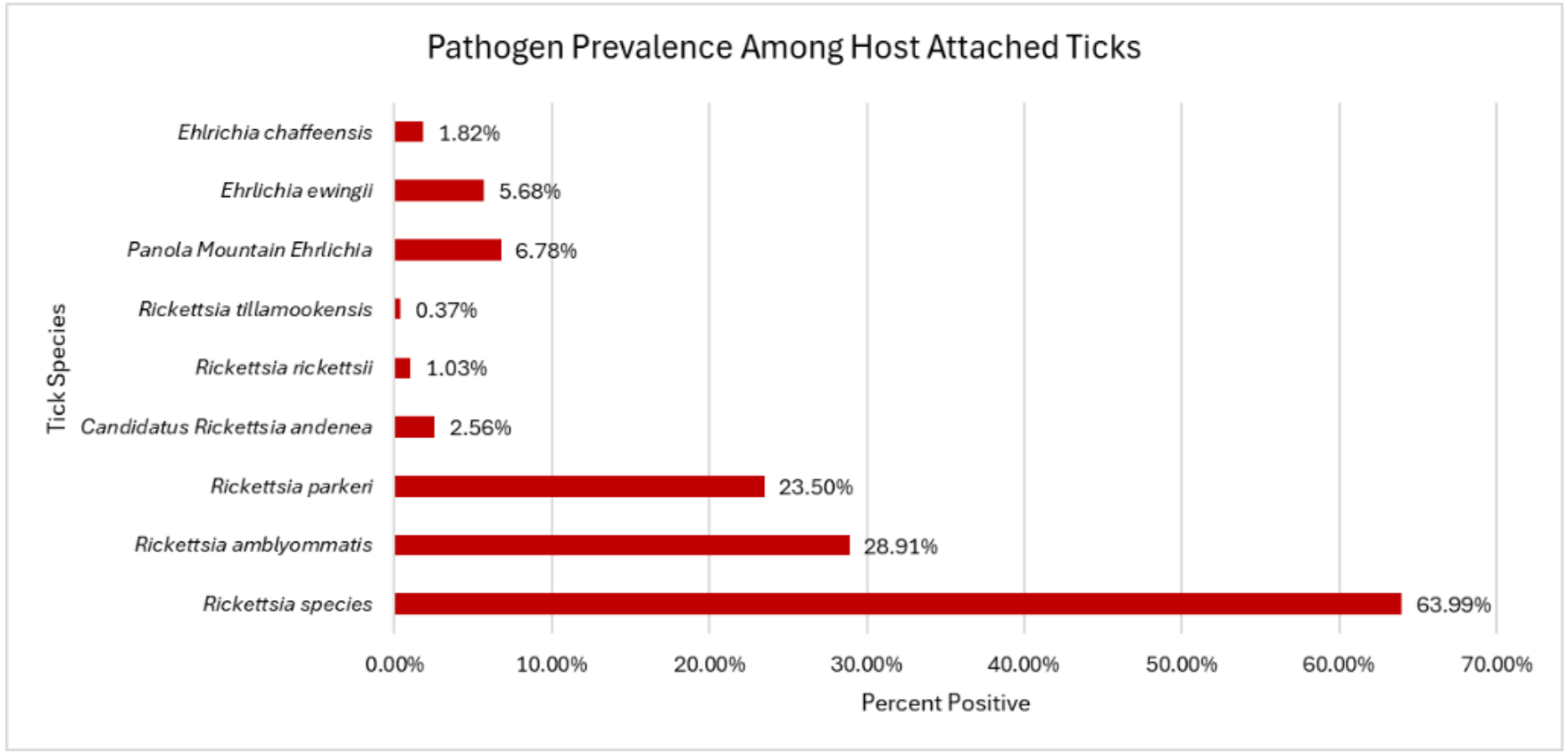
PATHOGEN PREVALENCE AMONG HOST-ATTACHED TICK



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SURVEILLANCE METHODS

Dragging/ Flagging

Carbon Dioxide Traps

Ticks Crawling on or Biting Collector

Public Submissions

Ticks Removed from Animals

!!!

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THE ROLE OF WILDLIFE SPECIALISTS

- High Volume of Tick Submissions
- Frequent Contact with At-Risk Animals
- Access to Diverse Environments
- Greater Tick Diversity
- Early Detection of Emerging Species
- Opportunities for Passive Surveillance
- Frontline Observers of Tick-Borne Disease

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HAEMAPHYSALIS LEPORISPALUSTRIS

- Commonly known as the Rabbit tick
- All stages- lagomorphs
- Immature stages- birds
- Rarely feed on humans
- Rarely found in the wild questing
- Vectors of: Rocky Mtn Spotted Fever, tularemia (within rabbit and rodent populations)
- Large infestations can weaken or kill small hosts

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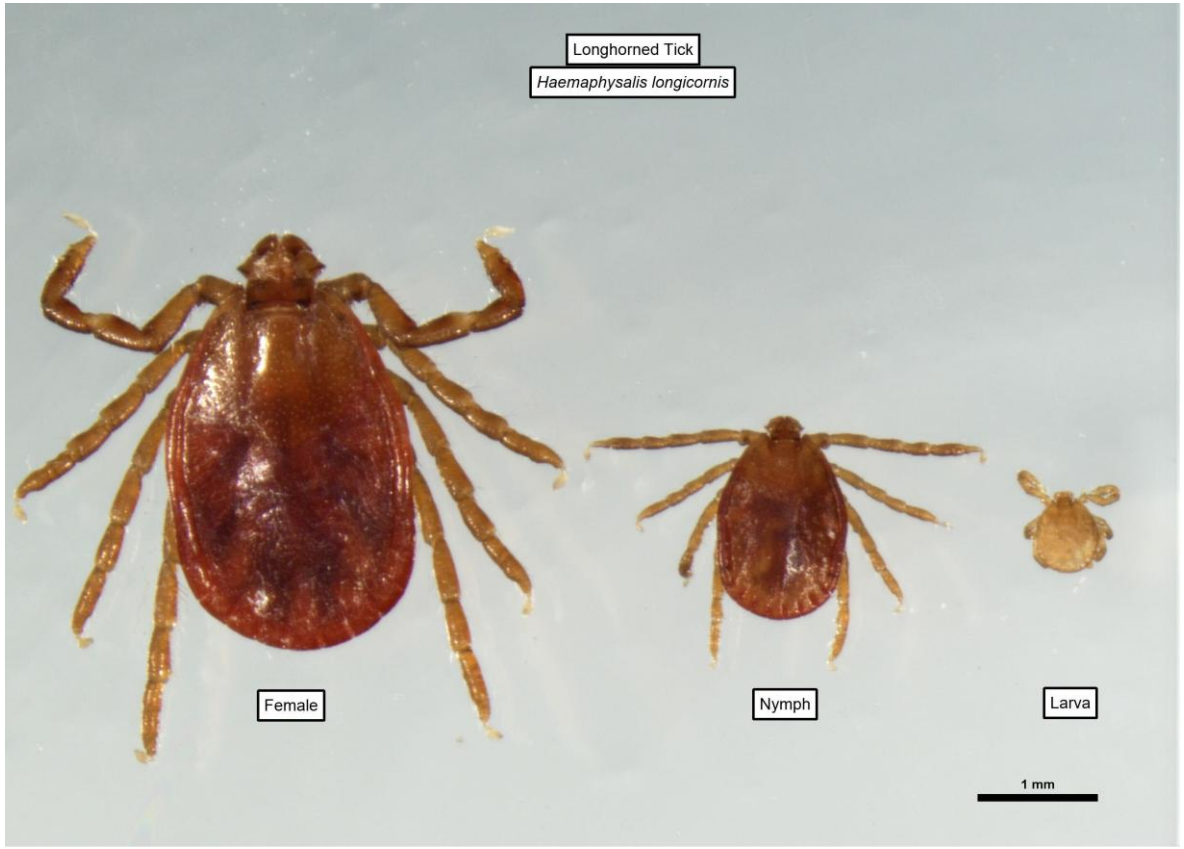
HAEMAPHYSALIS LONGICORNIS

- Commonly known as the Longhorned tick
- Invasive tick- serious threat to livestock in the U.S.
- Parthenogenesis- reproduces asexually = rapid infestation
- Exsanguination (fatal anemia) from blood loss
- Transmit *Theileria orientalis (intracellular protozoan*), which shows similar clinical symptoms to anaplasmosis in cattle



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H. LONGICORNIS STUDY

Asian Longhorned Tick – June 2022 Investigation

TICK COLLECTING

Perimeter ticks	1429
Block1	122
Block2	86
Block3	68
Block4	53
Block5	16
Block6	15
Body (noticed while walking around)	9

PATHOGEN TESTING RESULTS

	Anaplasmosis	Theileriosis	Lyme Disease
	A. Phagocytophilum	*T. orientalis*	*B. Burgdorferi*
Haemaphysalis longicornis	0%	1%	2.6%

BLOOD MEAL ANALYSIS

DEER	DOG	CATTLE	HUMAN
2%	49%	49%	*ON GOING*

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SO, HOW CAN YOU HELP?

Send to:

The Laboratory of Vector-borne and Zoonotic Diseases

Attn: Katherine Brown

915 Greene St. #327

Columbia, SC 29208

Email: kmb41@email.sc.edu

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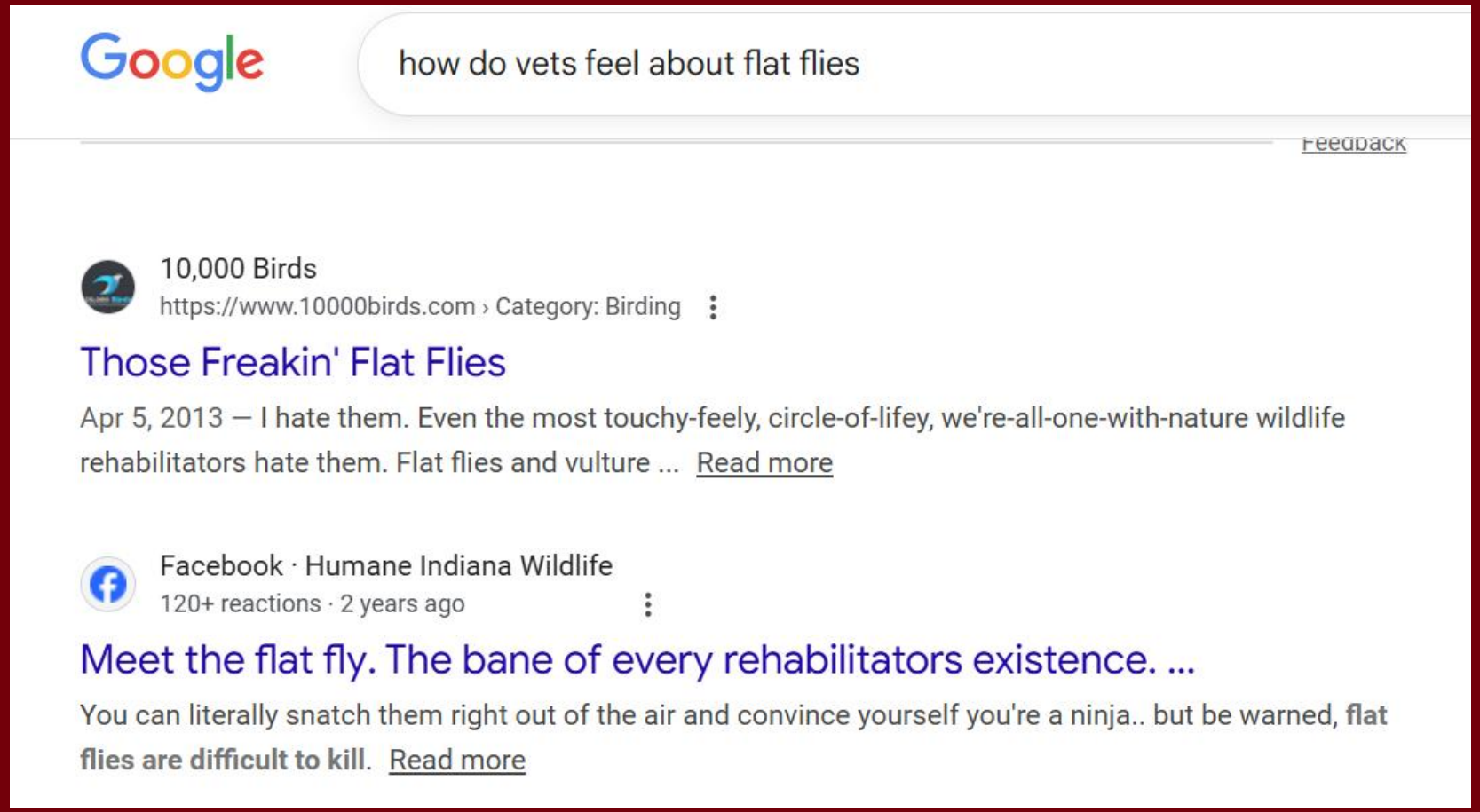

I hate them. Even the most touchy-feely, circle-of-lifey, we're-all-one-with-nature wildlife rehabilitators hate them. Flat flies and vulture vomit: either one can send an otherwise cheerful vet technician running from the room.

INTRODUCTION

- Louse flies (Diptera: Hippoboscidae), also known as keds or flat flies, are a small family of flies with 216 species known worldwide.
- Louse flies are ectoparasites of mammals and birds
- Associated with wildlife and highly specialized, so they are poorly studied
- Obligate parasites that feed on only blood and rarely spend time off their host
- Limited information on the prevalence by host, geographical distribution, and the factors that make their various host susceptible to infestation.
- Carry pathogens such as *Rickettsia* spp., *Borrelia* spp., *Anaplasma* spp., *Bartonella spp.*, *Trypanosoma spp.*, and West Nile virus.

AVIAN LIFE CYCLE

Female produces one larva at a time. Larva hatches in uterus and feeds on the “milk gland” for larval development

The female lays larva (prepupa), which then pupates (usually in the host’s nest)

Prepuparium

The adult fly emerges from pupa ready to find a host

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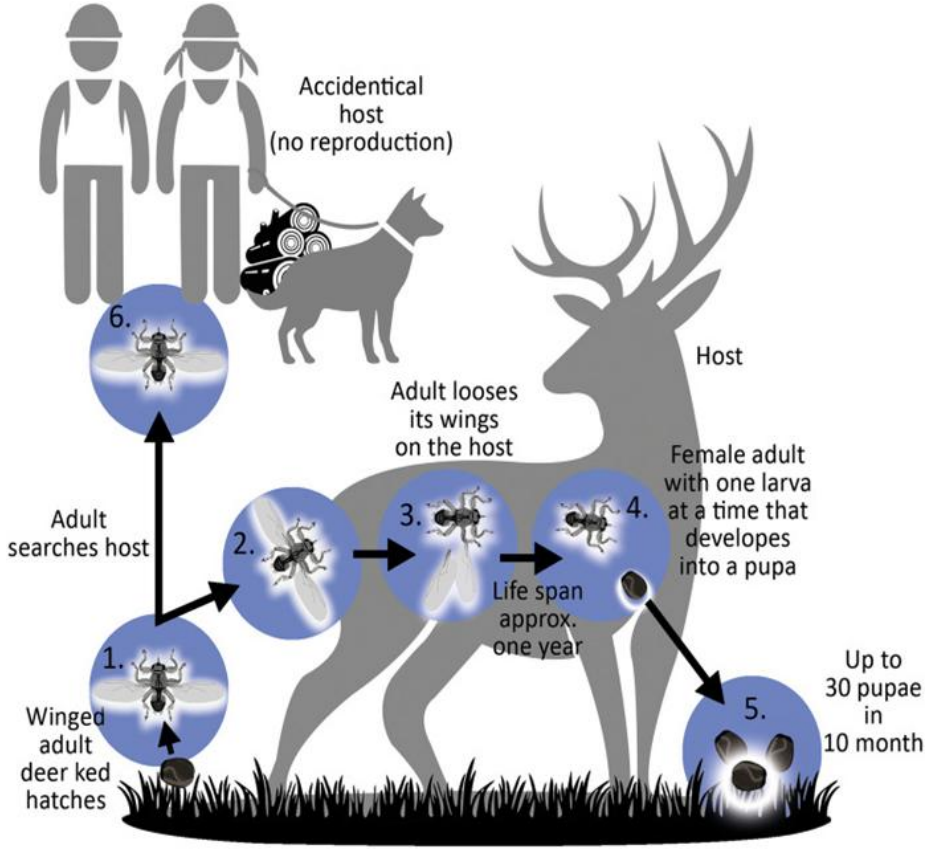
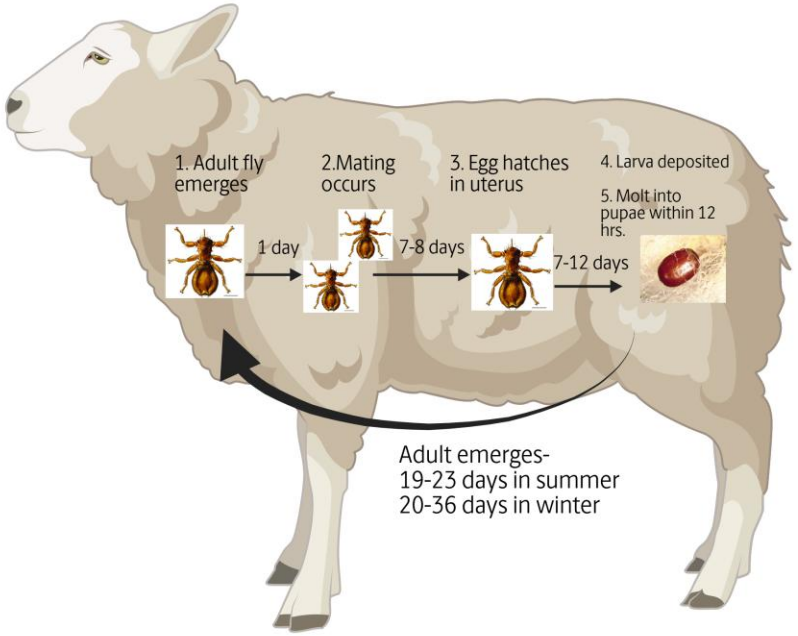
DEER KED VS. SHEEP KED LIFECYCLE





Braun, M., Klingelhöfer, D., Brüggmann, D., & Kramer, I. M. (2025). The role of deer keds (Diptera: Hippoboscidae: Lipoptena and Neolipoptena) in occupational and public health. *Journal of occupational medicine and toxicology (London, England)*, *20*(1), 45. https://doi.org/10.1186/s12995-025-00490-5

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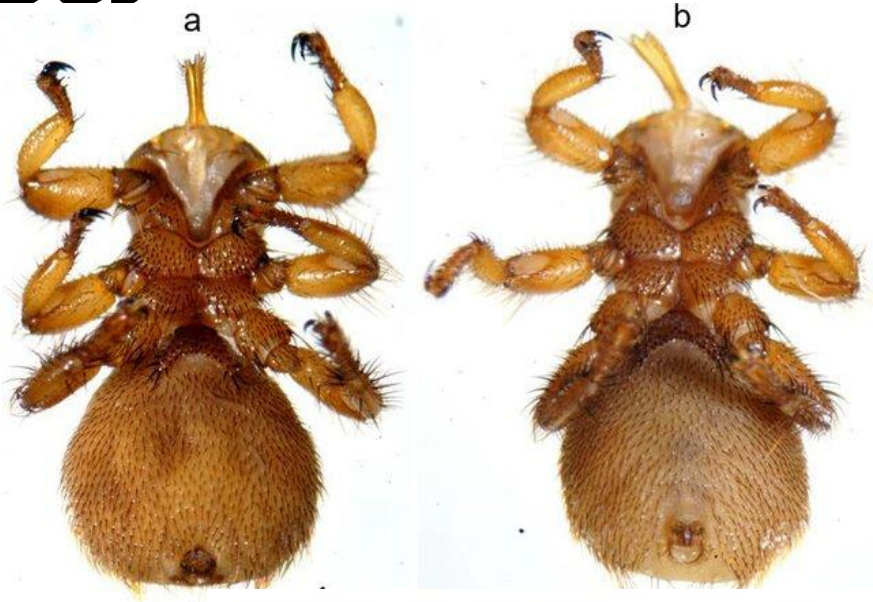
SHEEP KED (*MELOPHAGUS OVINUS*)

- Most studied due to its veterinary importance and the economic losses its infestation causes
- Infestation symptoms-
  - skin irritation, fleece damage, restlessness, anaemia, and injuries on the skin caused by host's attempt to alleviate the itching, leading to secondary infections and causing cutaneous myiasis
- Cause of economic losses on the host, due to effects on livestock production and reproductive performance of sheep
- Form hard nodules, known as cockle, on the sheep skin- annual economic impact of 1.6 million USD demonstrated in two Ethiopian tanneries
- Animals infested by *M. ovinus* obtain 3.6 kg less of gained weight and 11% less of wool production than ked-free lambs



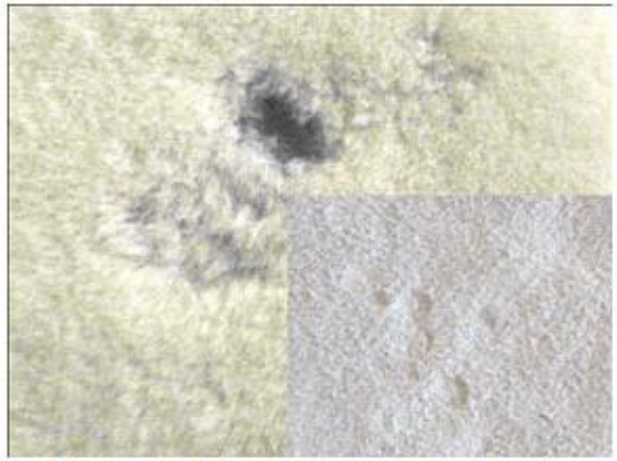


Figure 2: Hide damage due to sheep keds.

http://www.cleonscorner.com/Article005.aspx

Liu Y-H, He B, Li K-R, Li F, Zhang L-Y, Li X-Q, et al. (2019) First report of border disease virus in *Melophagus ovinus* (sheep ked) collected in Xinjiang, China. PLoS ONE 14(8): e0221435. https://doi.org/10.1371/journal.pone.0221435

SHEEP KED (*MELOPHAGUS OVINUS*)

- **Primary host-** Sheep
- **Other hosts-** European bison, goats, rabbits, dogs, foxes, humans
- **Distribution on the host's body-** Chest, forequarters, rib regions
- **Geographic Dist.-** Worldwide

- **Associated pathogens/parasites-**

Trypanosoma melophagium,
Theileria ovis,
Anaplasma ovis,
Bartonella spp.,
Borrelia burgdorferi sensu lato,
Rickettsia spp.,
Acinetobacter spp.,
Arsenophonus spp.,
Enterobacter spp.,
Shewanella spp.,
Halomonas spp.,
Bacillus spp.,
Staphylococcus spp.,
Wolbachia spp.,
Blue-tonguevirus,
BorderDiseaseVirus

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DEER KED (*LIPOPTENA CERVI*)

- Mostly associated with wildlife, especially cervids,
- Deer ked is responsible for major burden on cervids with up to 17,491 specimens recorded per individual and 100% of prevalence in flock
- Behavioural abnormalities (e.g., scratching, grooming and shaking the body, head and legs) have been demonstrated in reindeer (*Rangifer tarandus tarandus*)
- *L. cervi* has been reported in other mammal species, including humans, which are accidental hosts
- Humans may develop chronic dermatitis and allergic rhinoconjunctivitis
- Human diseases associated to *L. cervi* have been considered occupational conditions, as it affects workers in forests and national parks
- Interesting co-feeding with ticks on white-tailed deer with acquisition or transmission of vector-borne pathogens

https://entomologytoday.org/2024/10/01/deer-keds-fly-repellents-hunters-hikers/winged-deer-ked-lipoptena-cervi

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DEER KED (*LIPOPTENA CERVI*)

- **Primary host-** Cervids
- **Other hosts-** European bison, dogs, humans
- **Distribution on the host's body-** neck, abdominal region, groin, anal region, udder, perineal region, axilla
- **Geographic Dist.-** North America, Europe, Asia

- **Associated pathogens/parasites-**
- Bartonella spp.,
- Acinetobacter spp.,
- Anaplasma spp.,
- Rickettsia spp.,
- Borrelia burgdorferi,
- Trypanossomas spp.

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AVIAN LOUSE FLIES

- 75% of hippoboscids have birds as the primary/definitive hosts
- For wild birds, there is limited information on their competence as vectors of pathogens.
- For domesic birds, the pigeon fly, *P. canariensis*, is the only ked species known to parasitize, causing severe irritations that lead to mortality in young individuals
- *Icosta americana* has been regarded as a potential vector of the West Nile Virus

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AVIAN LOUSE FLIES

- **Primary host-** raptors, pigeons, osprey, turkeys, pelicans, quails, roadrunners, crows, etc.
- **Other hosts-** other birds
- **Distribution on the host's body-** NDA
- **Geographic Dist.-** Worldwide

- **Associated pathogens/parasites**
- West Nile virus
- *Haemoproteus columbae*
- *Haemoproteus maccallumi*
- *Haemproteus lopohortyx*
- NDA

AVIAN LOUSE FLY SURVEILLANCE

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VETERINARIAN/WILDLIFE PARTNERSHIPS

In 1996 a medical clinic was designed for the treatment of injured raptors. Approx. 150 raptors are treated each year.

CAROLINA
WILDLIFE CENTER
RESCUE. REHABILITATE. RELEASE.

A 501(c)(3) nonprofit. Treated and rehabilitated more than 55,000 animals representing 200 species.

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VETERINARY PARTNERS- NORTH CAROLINA

Raptor Hospital provides medical care for sick, injured, or orphaned raptor patients.

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SURVEILLANCE AUG '23- PRESENT

Truist Clinic for Raptors and Endangered Species- Riverbanks Zoo, Columbia, SC

Birds n=76
Birds w/flies n=26
Flies n= 86 (approx.)
Aug '23- May '25

CAROLINA WILDLIFE CENTER
RESCUE. REHABILITATE. RELEASE.

Birds n=3 (all WNV (-))
Flies n=7 (not yet tested)
March '25

CAROLINA RAPTOR CENTER

Birds n= 32 (4 WNV (+))
Flies n=145 (not yet tested)
Aug '25 -Sept '25

USC LOUSE FLY COLLECTION LOG

MONTH:

	DATE	BIRD SPECIES	DESCRIPTION OF BIRD'S HEALTH	BIRD ORIGIN (COUNTY)	DISTRIBUTION ON HOST'S BODY (CHEST, NECK, WING)	TOTAL # OF KEDS
1						
2						

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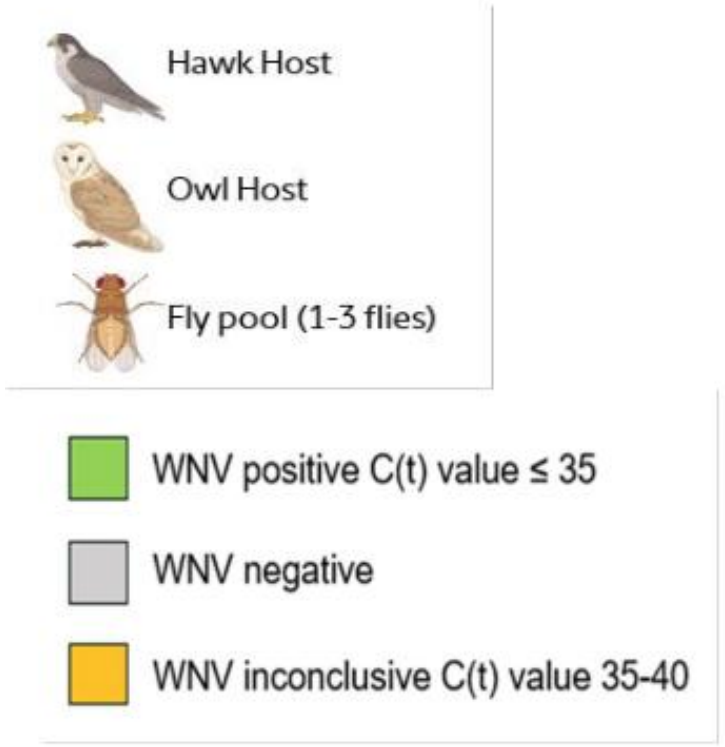
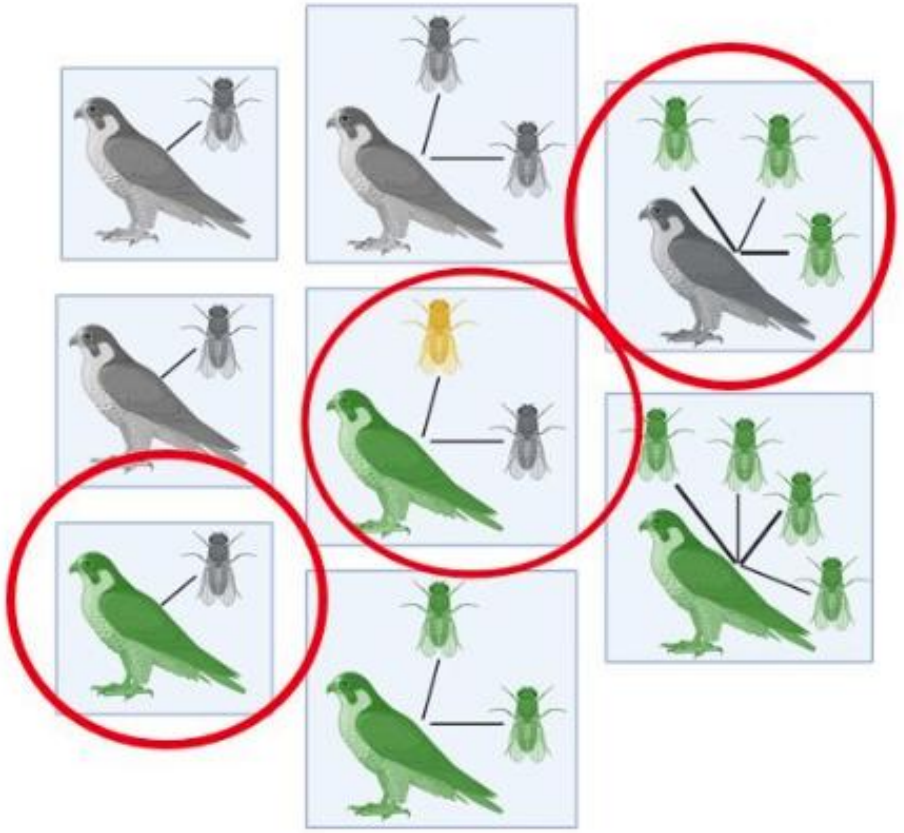
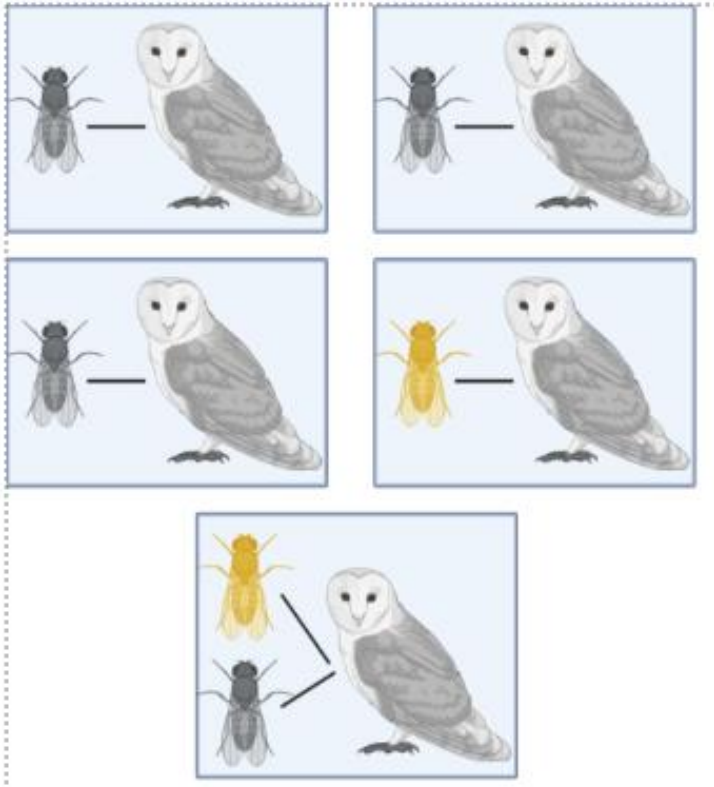
PCR TESTING RESULTS- LOUSE FLIES AND RAPTORS

APPROX. 42% OF KED POOLS (N=36) POSITIVE FOR WEST NILE VIRUS
APPROX. 31% OF BIRDS (N=13) POSITIVE FOR WEST NILE VIRUS







Owls

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LOUSE FLY SPECIES FOUND

A.

Icosta rufiventris

B.

Icosta americana

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- **Table 1.** Complete microbial composition results by *Icosta* species. Non-zero abundances are shaded and in bold, with the greatest species abundance is highlighted in green and second most abundant species highlighted in yellow. Species found in negative controls are in red text.

Bacterial Species	I. americana 9/28/23	I. americana 10/5/23	I. americana 10/18/23	I. americana 9/4/24	I. rufiventris 12/11/24
Unknown	**0.40%**	0.00%	0.00%	**0.05%**	**0.05%**
Corynebacterium auriscanis	**0.13%**	0.00%	0.00%	0.00%	0.00%
Microbacterium paraoxydans	0.00%	**0.37%**	0.00%	0.00%	0.00%
Propionibacterium acnes	**0.12%**	**0.75%**	0.00%	**0.15%**	0.00%
Pinus wallichiana	0.00%	0.00%	0.00%	**0.44%**	0.00%
Bacillus cereus	0.00%	0.00%	0.00%	**0.10%**	0.00%
Staphylococcus capitis	**1.09%**	0.00%	0.00%	0.00%	0.00%
Staphylococcus capitis-caprae	0.00%	**0.31%**	0.00%	0.00%	0.00%
Staphylococcus epidermidis	0.00%	0.00%	**5.35%**	**0.15%**	0.00%
Staphylococcus kloosii	**6.49%**	0.00%	0.00%	0.00%	0.00%
Staphylococcus sciuri	0.00%	0.00%	0.00%	**0.24%**	0.00%
Lactococcus lactis	0.00%	**0.01%**	0.00%	0.00%	0.00%
Anaerococcus sp31227	0.00%	0.00%	**15.34%**	0.00%	0.00%
Veillonella sp37198	0.00%	**0.15%**	0.00%	0.00%	0.00%
Methylocella palustris	0.00%	**0.11%**	0.00%	0.00%	0.00%
Bradyrhizobium denitrificans-oligotrophicum	**0.63%**	0.00%	0.00%	0.00%	0.00%
Bradyrhizobium elkanii-pachyrhizi	**0.95%**	0.00%	**5.81%**	0.00%	0.00%
Pinus sp46807	0.00%	0.00%	0.00%	**0.10%**	0.00%
Rickettsia sp47024	0.00%	0.00%	0.00%	0.00%	**21.67%**
Sphingomonas mali	0.00%	**0.20%**	0.00%	0.00%	0.00%
Delftia lacustris	0.00%	0.00%	**4.15%**	**0.18%**	0.00%
Schneideria sp58296	**9.25%**	**97.23%**	**48.25%**	**41.81%**	**3.62%**
Arsenophonus sp58072-symbiont	**0.02%**	0.00%	0.00%	0.00%	0.00%
Arsenophonus symbiont	**34.49%**	0.00%	0.00%	0.00%	**74.66%**
Escherichia coli	**0.52%**	**0.28%**	**1.18%**	0.00%	0.00%
Pectobacterium carotovorum	**44.96%**	0.00%	0.00%	**56.75%**	0.00%
Pasteurella sp62252	0.00%	0.00%	0.00%	**0.03%**	0.00%
Pseudomonas aeruginosa	**0.95%**	**0.60%**	**19.92%**	0.00%	0.00%

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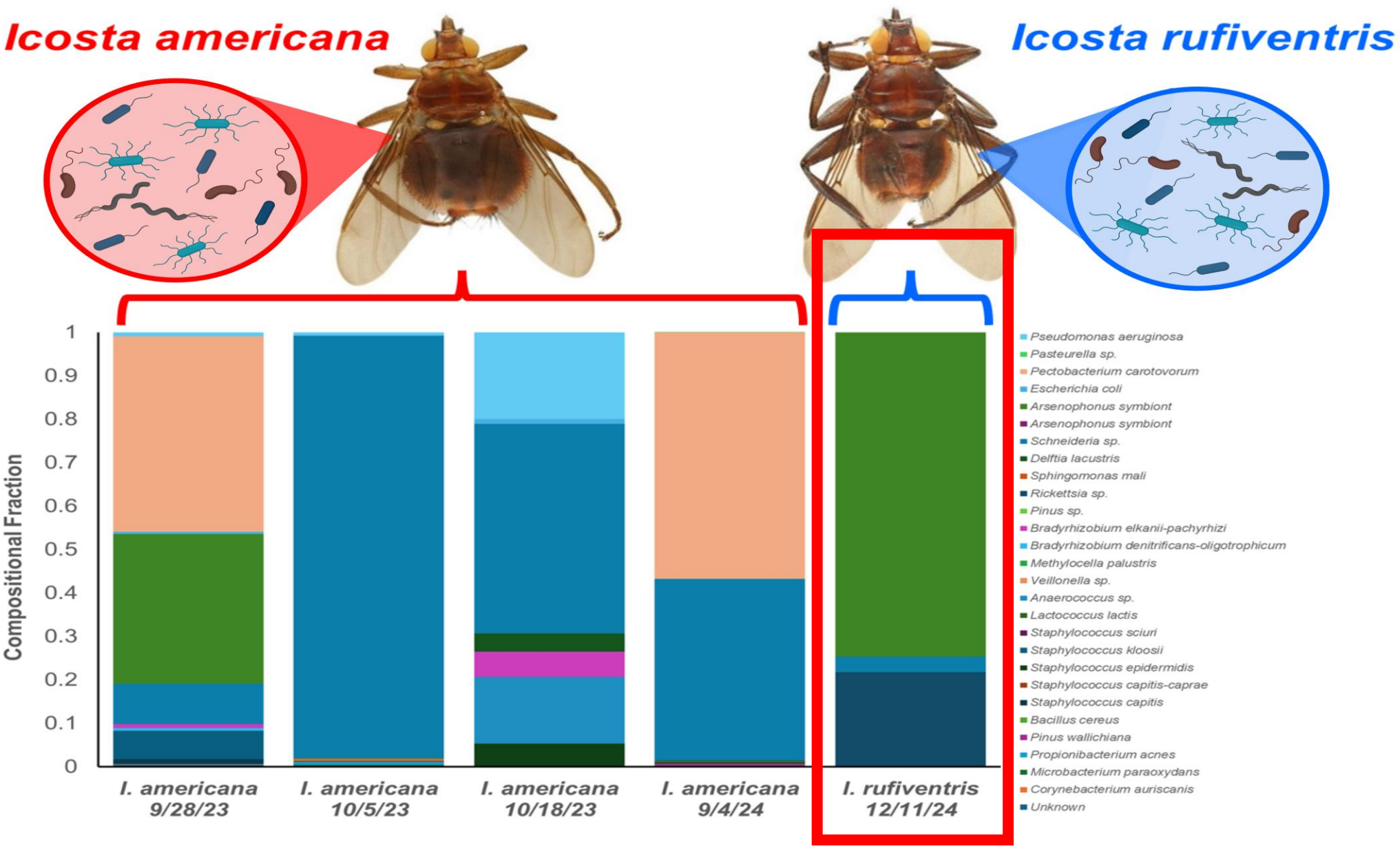
Icosta americana
Icosta rufiventris
Compositional Fraction
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
I. americana 9/28/23
I. americana 10/5/23
I. americana 10/18/23
I. americana 9/4/24
I. rufiventris 12/11/24
Pseudomonas aeruginosa
Pasteurella sp.
Pectobacterium carotovorum
Escherichia coli
Arsenophonus symbiont
Arsenophonus symbiont
Schneideria sp.
Delftia lacustris
Sphingomonas mali
Rickettsia sp.
Pinus sp.
Bradyrhizobium elkanii-pachyrhizi
Bradyrhizobium denitrificans-oligotrophicum
Methylocella palustris
Veillonella sp.
Anaerococcus sp.
Lactococcus lactis
Staphylococcus sciuri
Staphylococcus kloosii
Staphylococcus epidermidis
Staphylococcus capitis-caprae
Staphylococcus capitis
Bacillus cereus
Pinus wallichiana
Propionibacterium acnes
Microbacterium paraoxydans
Corynebacterium auriscanis
Unknown

OTHER POTENTIAL SPECIES

Icosta angustifrons?

- Found throughout the American continent
- Primary hosts- owls, hawks, falcons
- NDA on pathogens/parasites

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ORNITHOICA VICINA

Photo credit- Carolina Raptor Center

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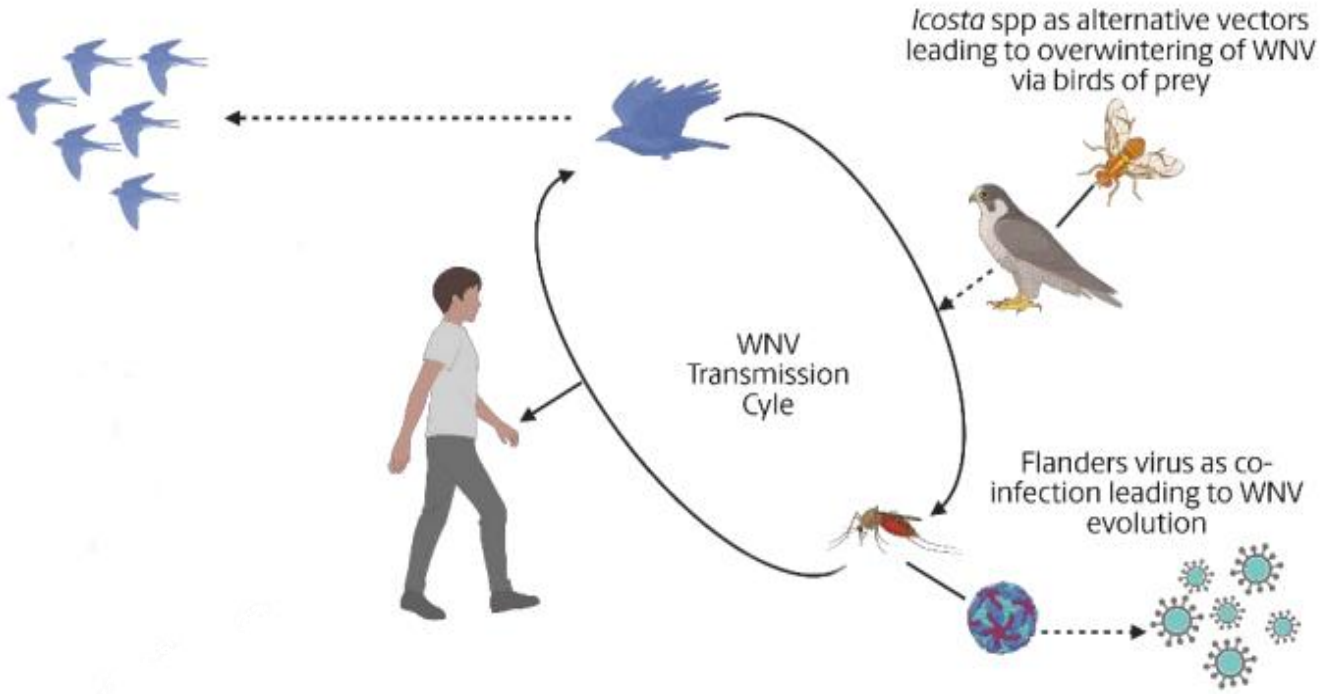
PUBLIC HEALTH CONCERN



- **How do avian louse flies fit into the West Nile virus transmission cycle?**

FUTURE DIRECTIONS

- Find funding mechanisms in order to-
  - Send off samples for ID
  - **Genome sequencing**
  - PCR testing
  - Dissection methods and tools
  - Publish!!!
  - Pay partners!

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THANK YOU!

CAROLINA RAPTOR CENTER

CAROLINA WILDLIFE CENTER
RESCUE. REHABILITATE. RELEASE.

Katherine Brown
Field Research Manager
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SCAN HERE for more info on The Nolan Lab!

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