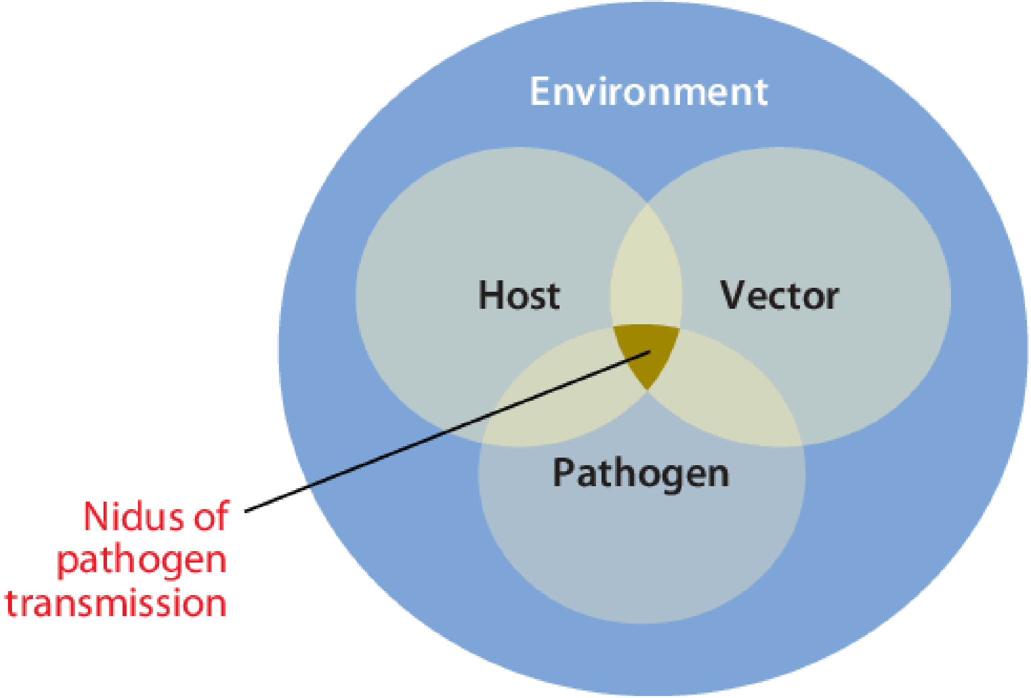
Invasive Reptile-Mediated Risk of Mosquito-Borne Pathogen Transmission

Nathan Burkett-Cadena, PhD
Associate Professor
University of Florida
Florida Medical Entomology Laboratory
Vero Beach, FL USA

University of Florida
Invasion Science Research Institute (ISRI)
Invasion Science Research Symposium
Gainesville, FL | May 6-9, 2024.

Spatial epidemiology of vector-borne disease

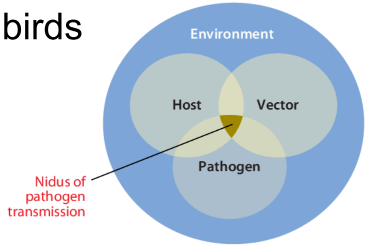


Conceptual nidus showing how vector, host, and pathogen populations intersect within a permissive environment to enable pathogen transmission. From Reisen (2010) Ann. Rev. Entomol.

Diversity of vector-borne disease

Mosquito-borne diseases	Vertebrate host
Filariasis	Humans, wild primates
Malaria	Humans, wild primates
Dengue fever	Humans, wild primates
Yellow fever	Humans, wild primates
Chikungunya virus	Humans, wild primates
O'nyong nyong fever	Humans
St. Louis encephalitis	Columbiform birds
West Nile	Passeriform birds
Murray Valley encephalitis	Wading birds
Eastern equine encephalitis	Songbirds
Western equine encephalitis	Birds, rabbits, reptiles
Japanese encephalitis	Wading birds, pigs
LaCrosse encephalitis	Squirrels, foxes
Everglades virus	Rodents
Jamestown Canyon virus	Deer
Ross River virus	Marsupials, birds
Rift Valley fever	Ungulates

Tick-borne disease	Vertebrate host
Rocky Mountain spotted fever	Diverse mammals
Tularemia	Rabbits, carnivores
Lyme disease	Rodents
Boutonneuse fever	Small mammals, dogs
African tick bite fever	Mammals
Erlichiosis	Deer, dogs
Anaplasmosis	Rodents, deer, dogs
Q fever	Livestock
Tick-borne relapsing fever	Various mammals
Babesiosis	Rodents, cattle
Tick-borne encephalitis	Rodents, shrews, carnivores
Kyasanur forest disease	Monkeys, other mammals
Powassan encephalitis	Rodents, hares, carnivores
Colorado tick fever	Rodents, other mammals
Crimean-Congo hem. fever	Hares, hedgehogs, others



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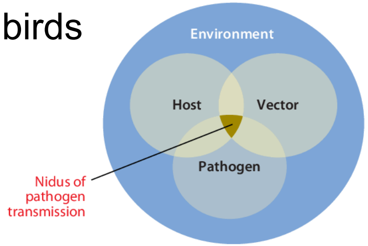
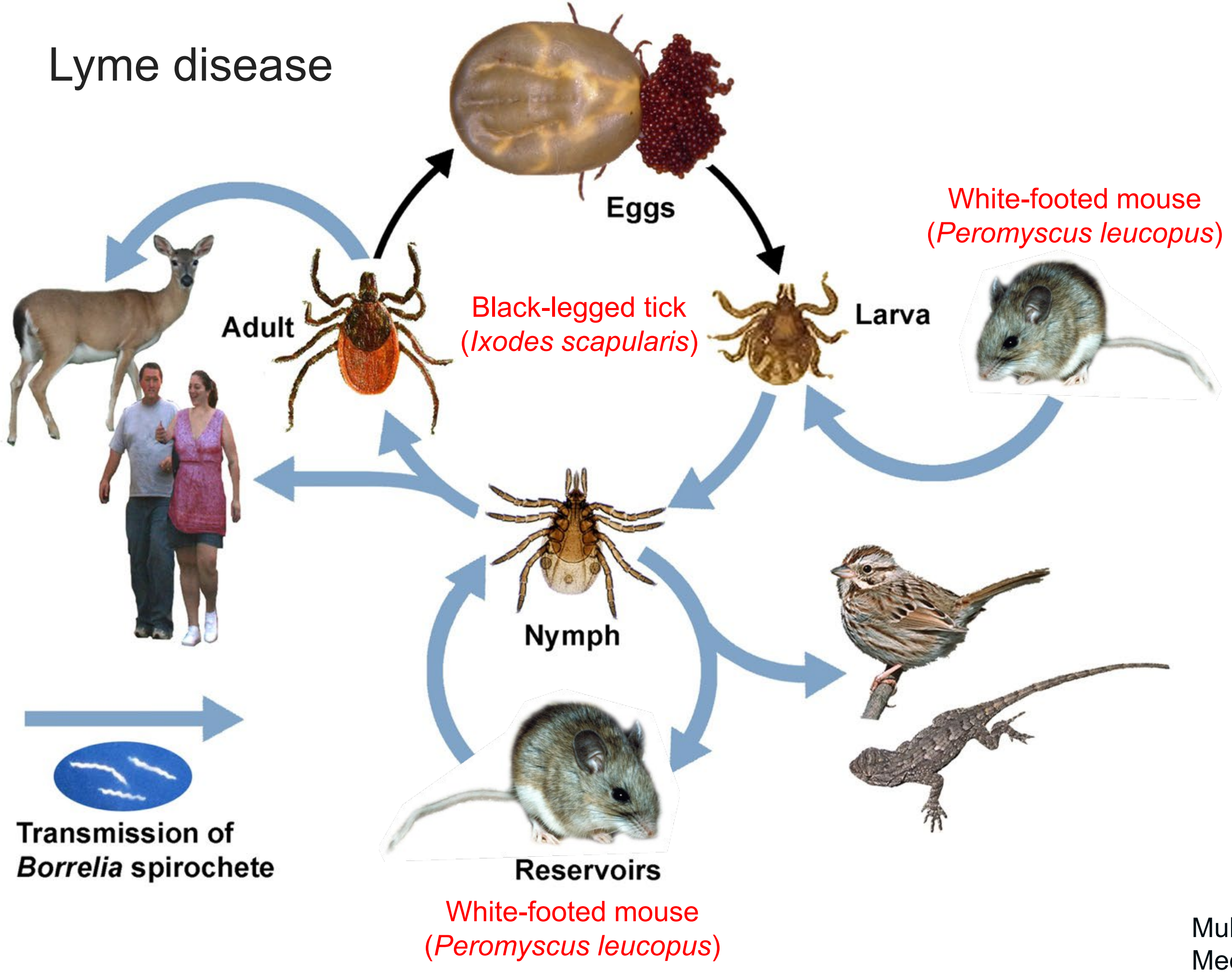
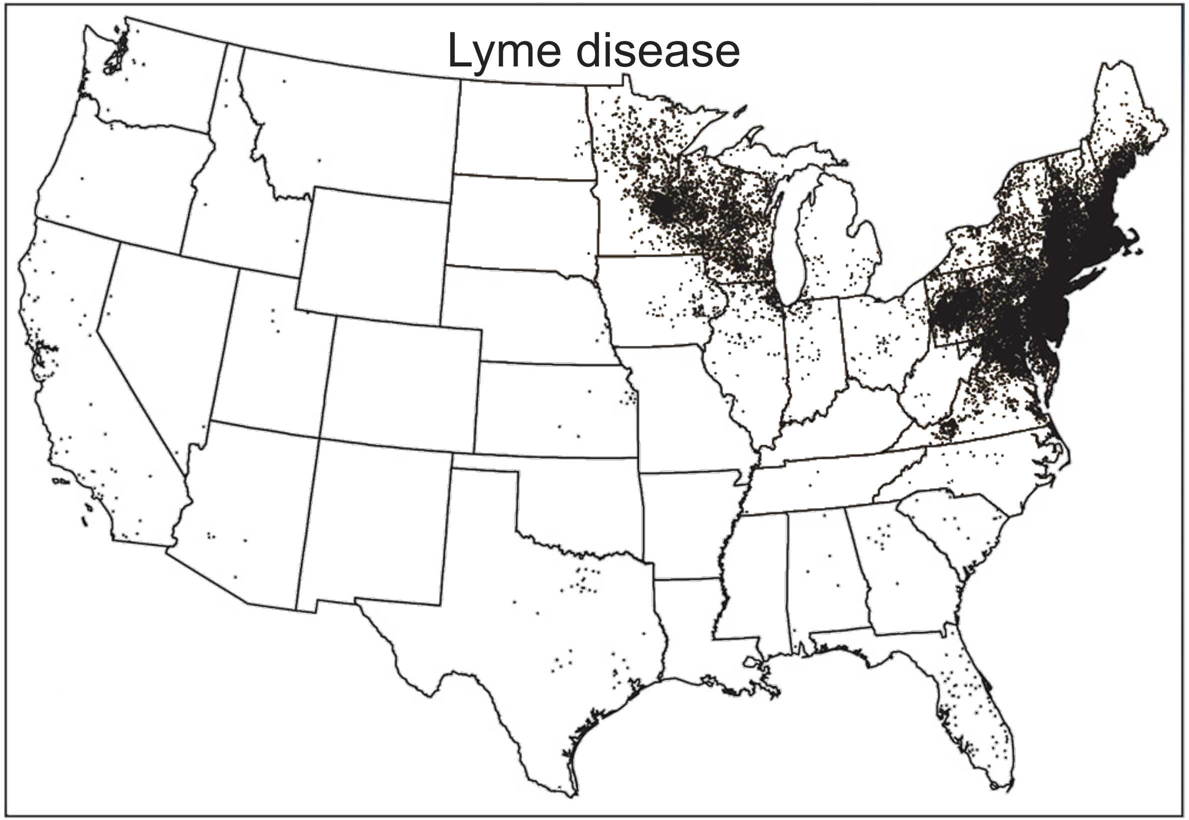


Lyme disease

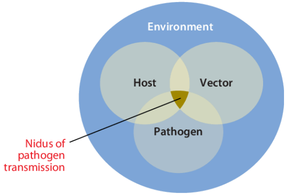


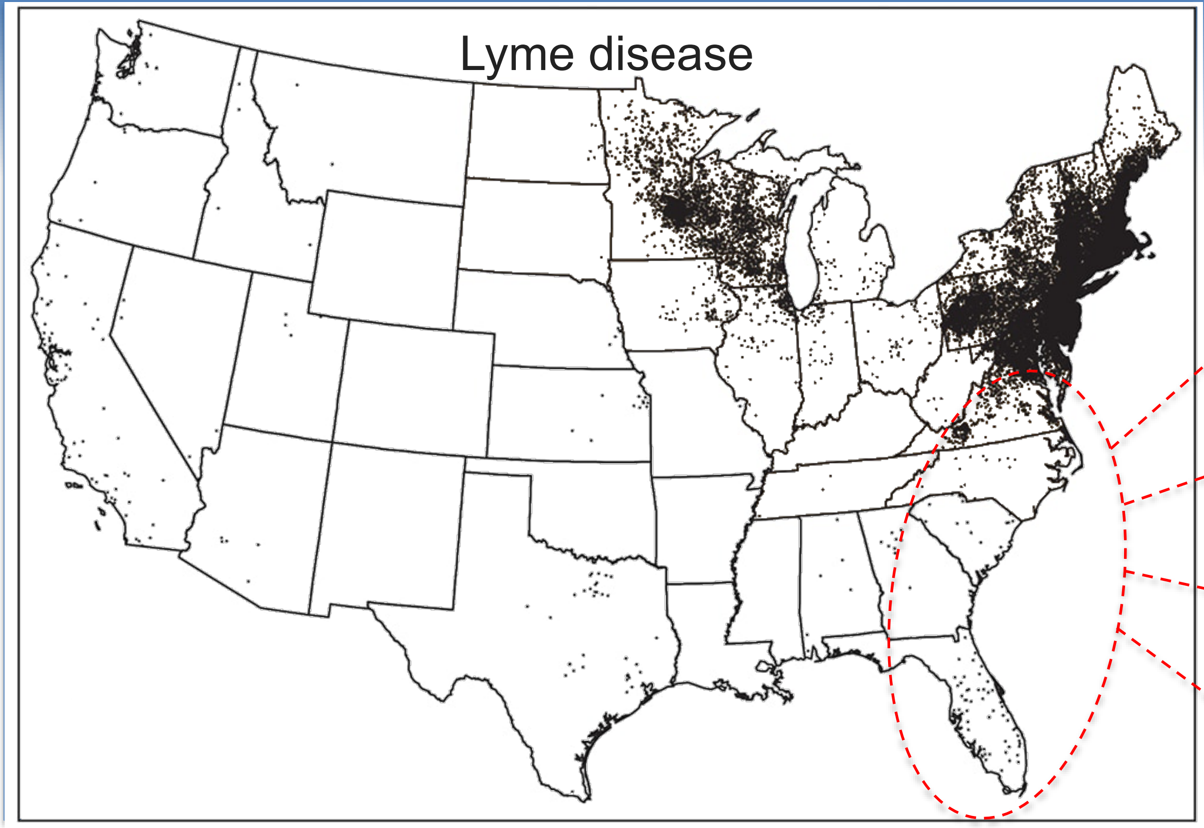
Mullen and Durden (2009)
Med. Vet. Entomol.

Lyme disease



Average number of confirmed Lyme disease cases, by county of residence United States, 2008–2015 (CDC)





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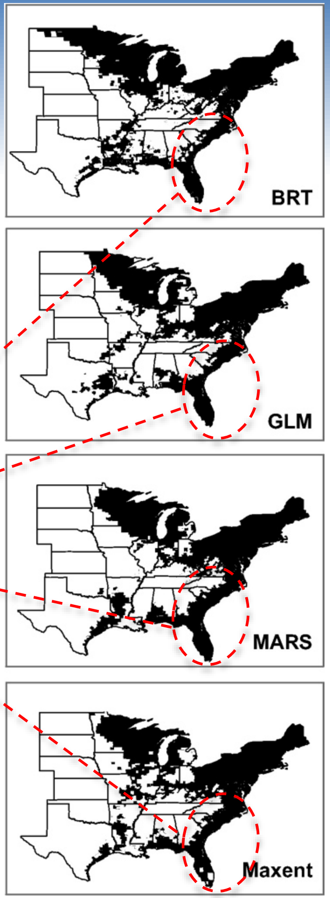
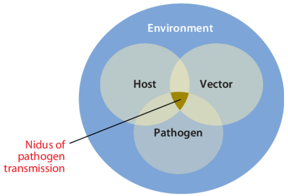
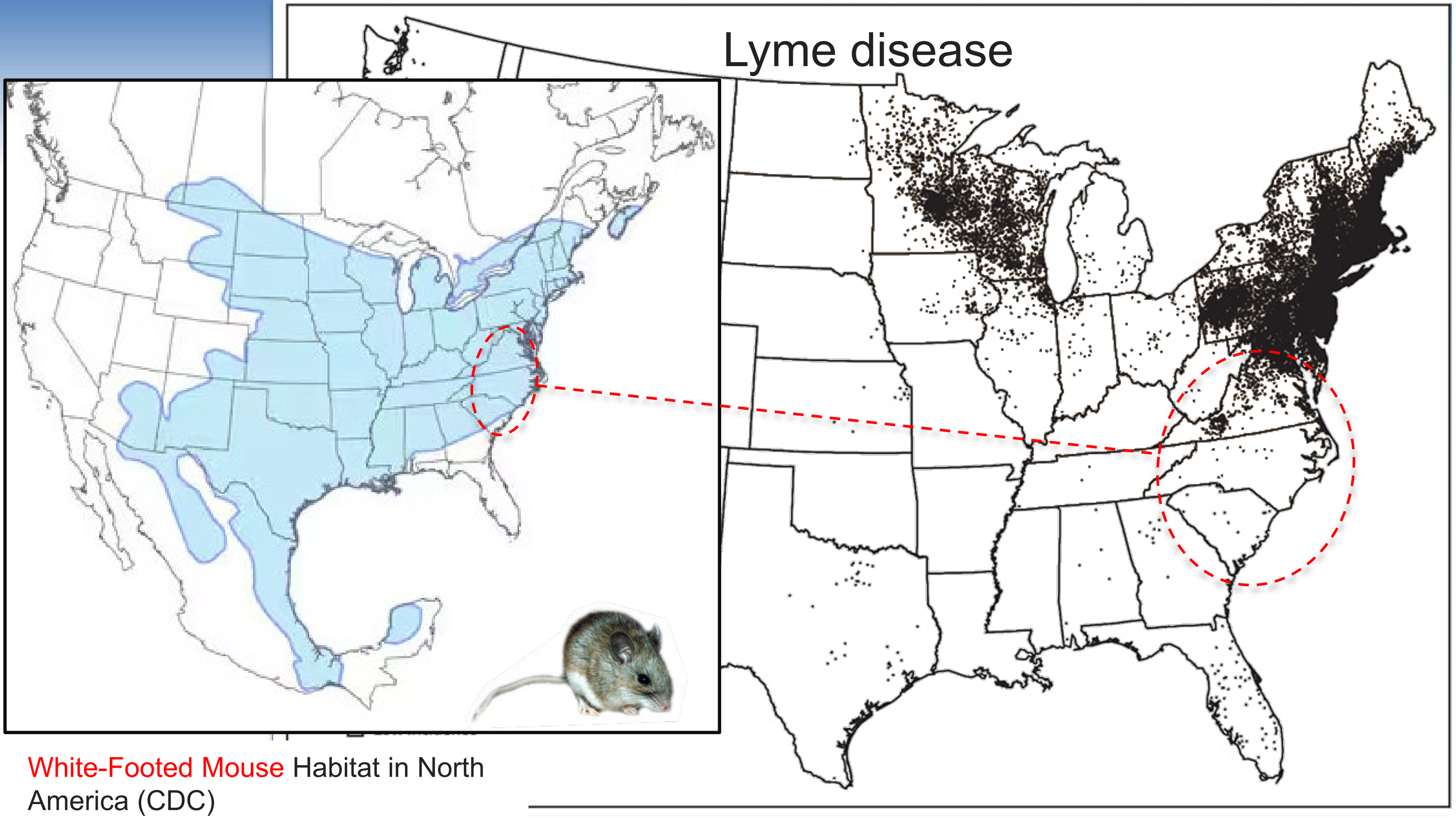




Maps depicting the predicted distribution of *Ixodes scapularis* by individual optimized models.

Hahn et al. 2016. J Med Entomol



White-Footed Mouse Habitat in North America (CDC)

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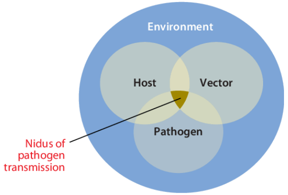

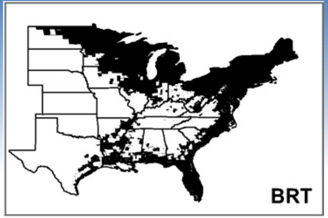

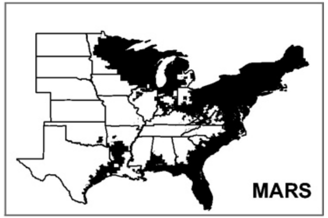

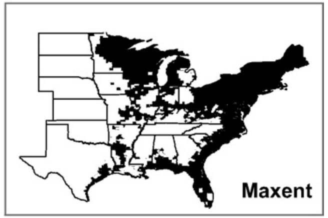

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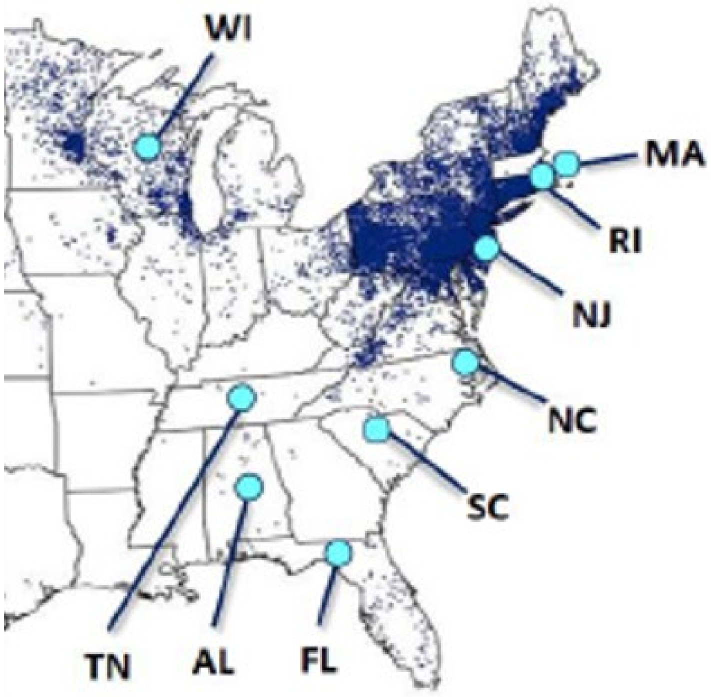
PLOS BIOLOGY 2021

Lyme disease cases



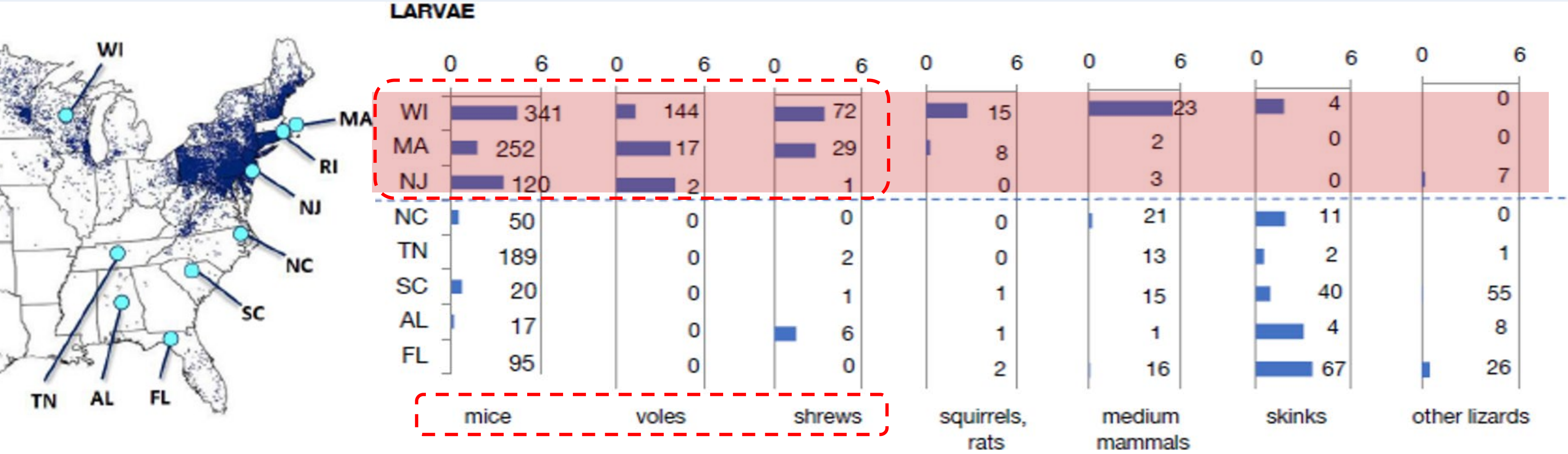
RESEARCH ARTICLE

Why Lyme disease is common in the northern US, but rare in the south: The roles of host choice, host-seeking behavior, and tick density

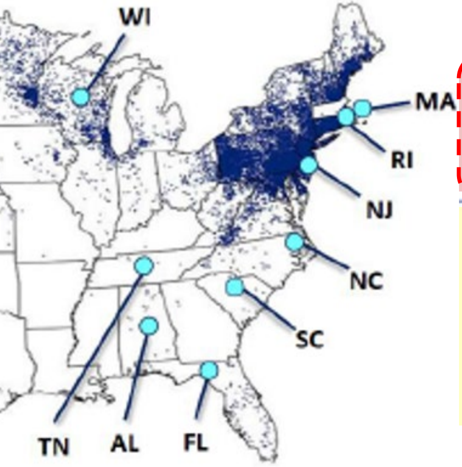
Howard S. Ginsberg[1,2]*, Graham J. Hickling[3], Russell L. Burke[4], Nicholas H. Ogden[5], Lorenza Beati[6], Roger A. LeBrun[2], Isis M. Arsnoe[7], Richard Gerhold[3], Seungeun Han[8], Kaetlyn Jackson[4], Lauren Maestas[3], Teresa Moody[3], Genevieve Pang[7], Breann Ross[4], Eric L. Rulison[2], Jean I. Tsao[7]

- Characterized tick host associations at 8 sample sites in the eastern U.S., along a latitudinal gradient (MA to F).
- Screened ticks for Lyme disease spirochete.

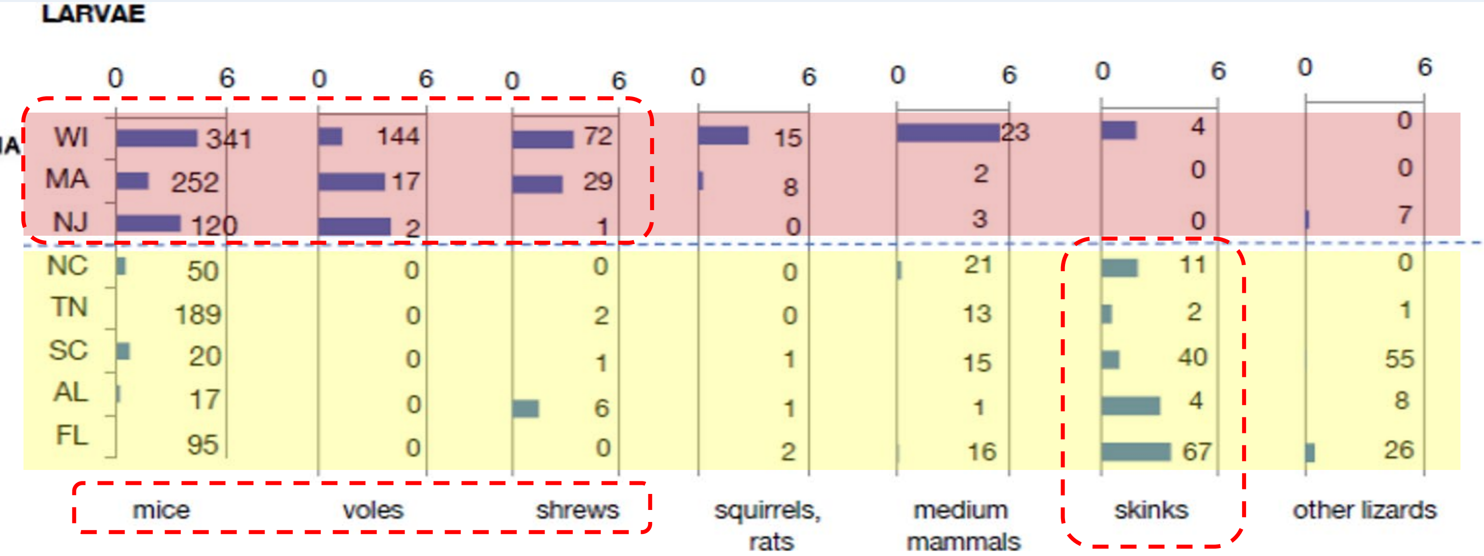
In the northern states (WI, MA/RI, & NJ), most ticks attached to mice, voles or shrews

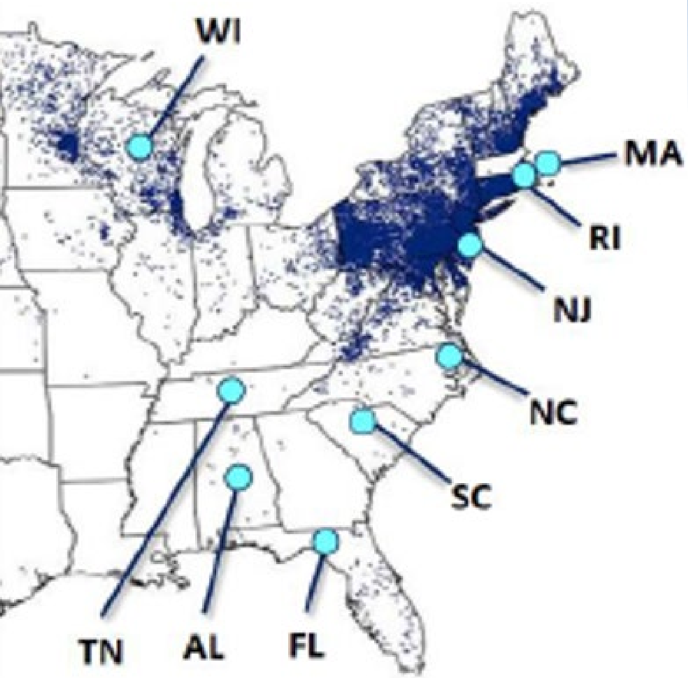


In the southern states (NC to FL), most ticks were found on skinks (a type of lizard).



Cases of Lyme disease





Cases of Lyme disease

"Our results indicate that the north-south trend in the prevalence of tick infection with *B. burgdorferi*, *and the associated gradient in human Lyme disease*, is due to the selective attachment of ticks to lizards, especially skinks, in southern states." Ginsberg et al. 2021

- Lizards do not support replication of the Lyme disease spirochete.
- Rodents do.
- The type of animal bitten by the vector has a very strong influence on transmission.

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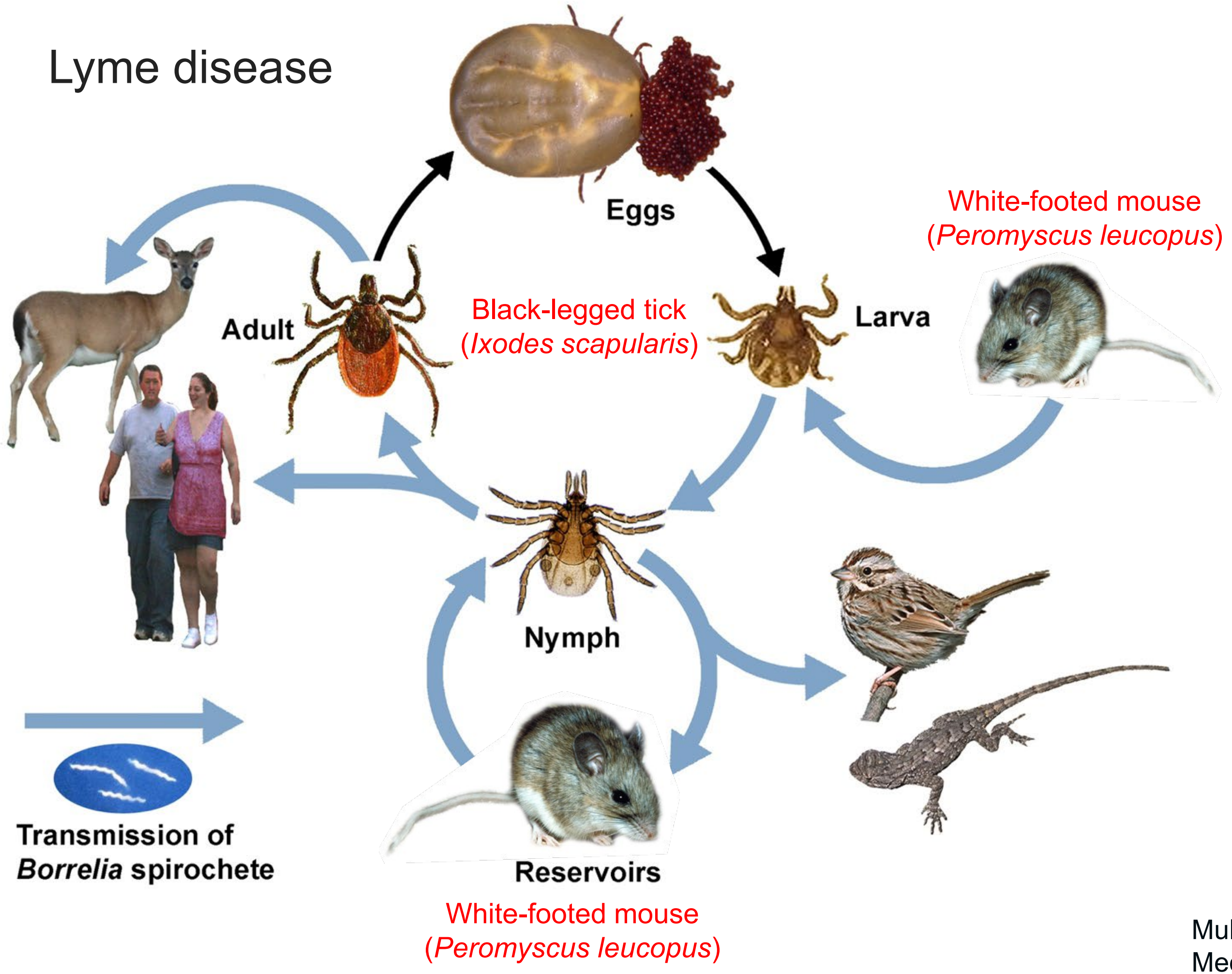
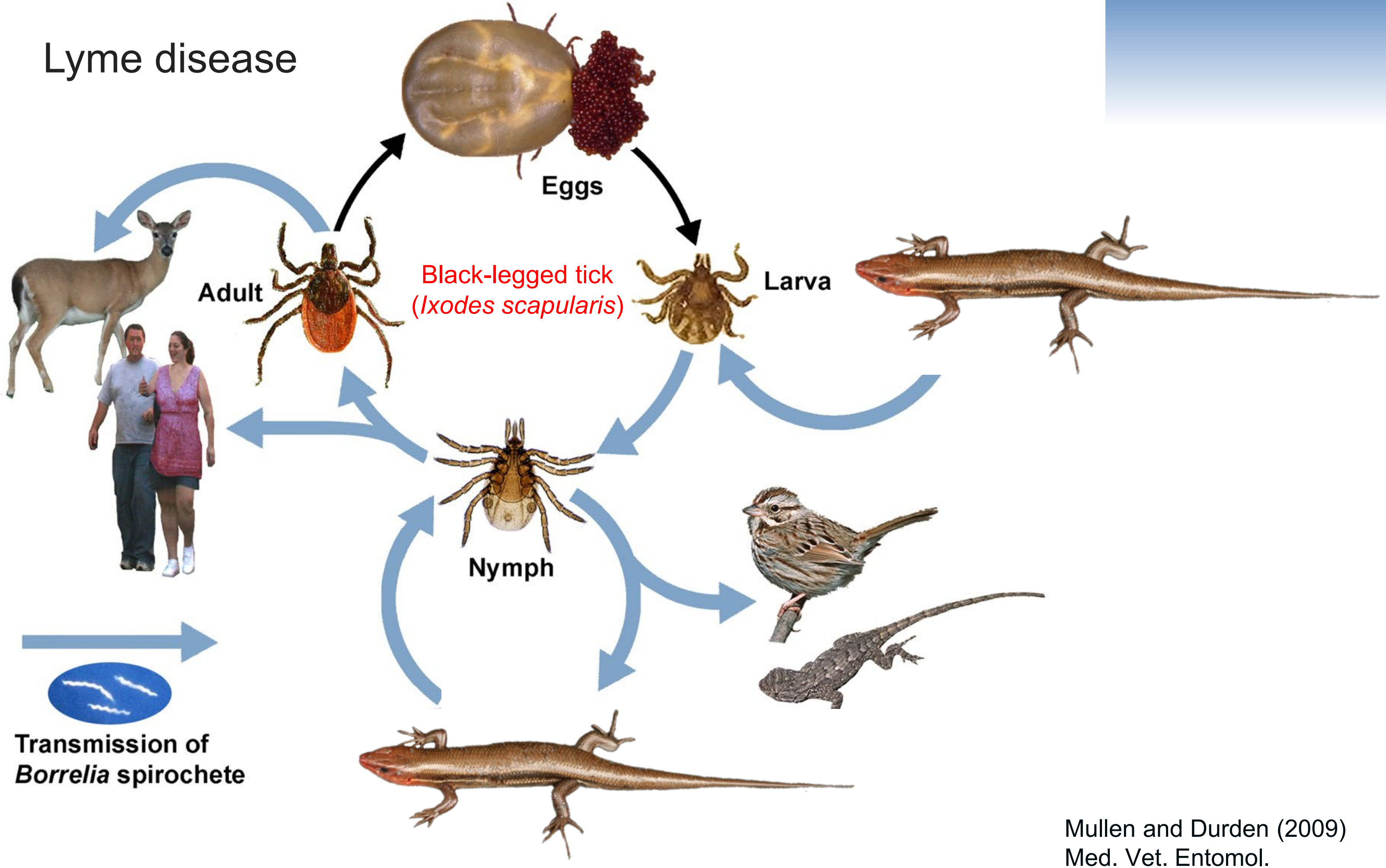
Lyme disease



Mullen and Durden (2009)
Med. Vet. Entomol.

Lyme disease



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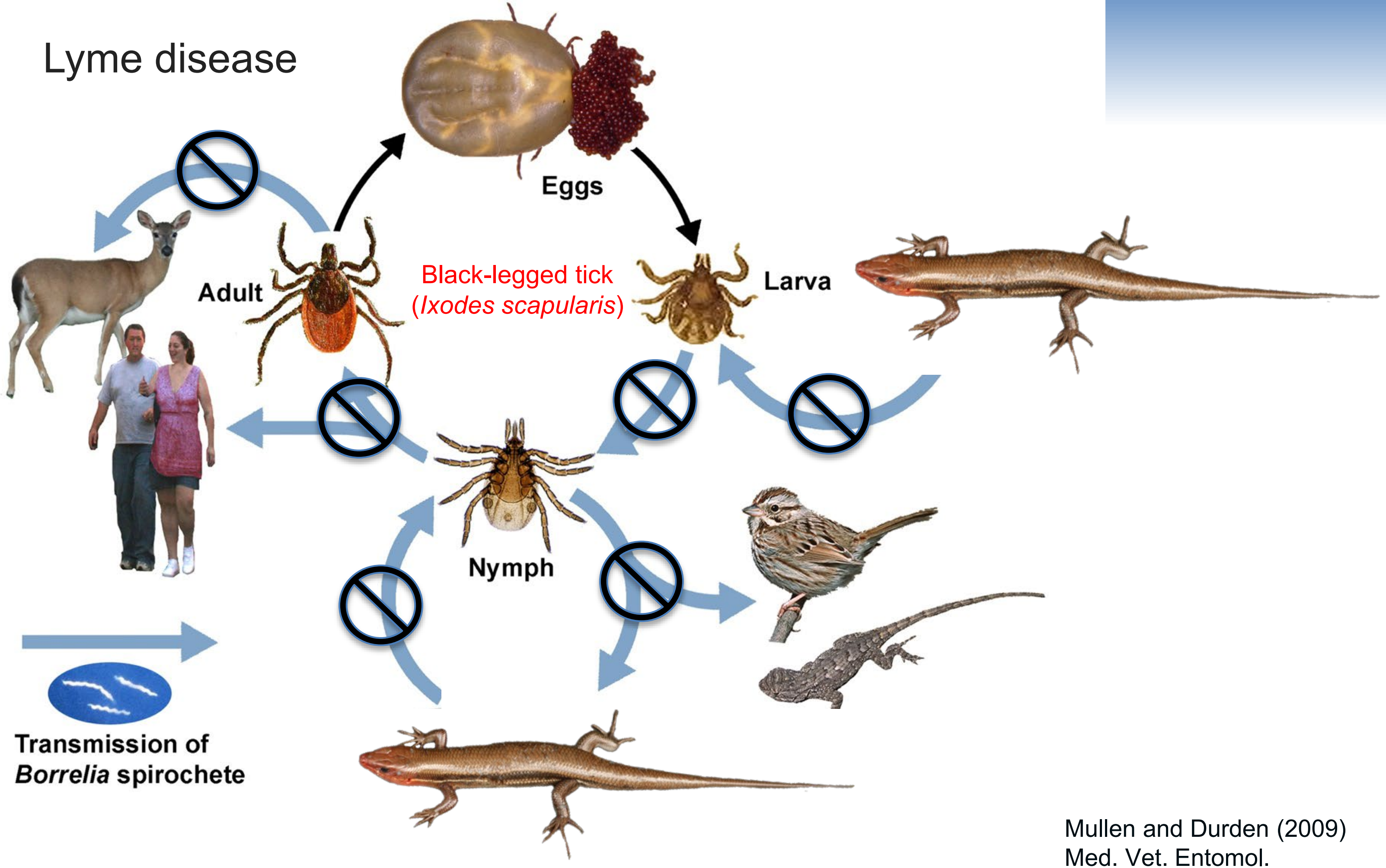

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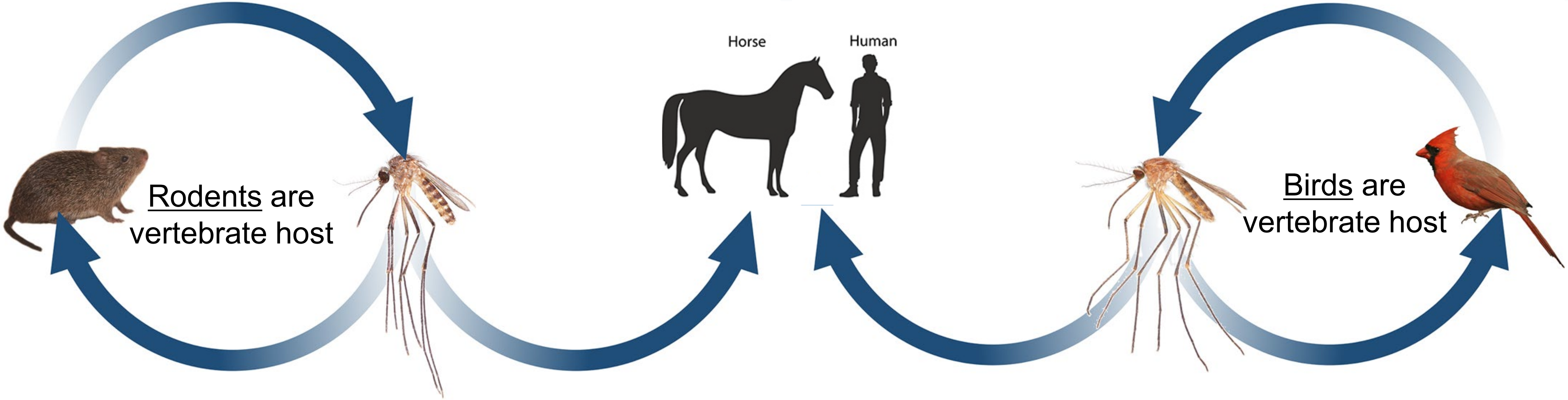
Mosquito-borne viruses in Florida



Everglades virus

Mahogany Hammock virus

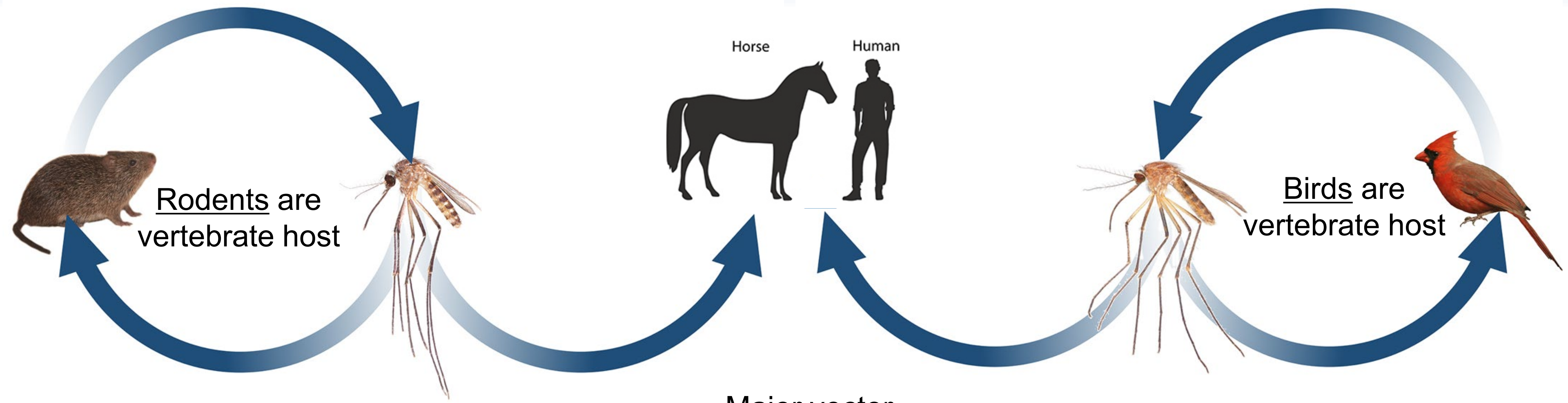
Gumbo Limbo virus

Eastern Equine Encephalitis virus

St. Louis Encephalitis virus

West Nile virus

Mosquito-borne viruses in Florida



Major vector

Everglades virus	*Culiseta melanura*	Eastern Equine Encephalitis virus
Mahogany Hammock virus	*Culex cedecei*	St. Louis Encephalitis virus
Gumbo Limbo virus	*Culex nigripalpus*	West Nile virus
	Culex quinquefasciatus	

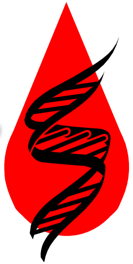
Blood meal analysis - Collection of techniques for determining the host animals bitten by blood-feeding organisms.

Blood meal analysis using PCR

Erik Blosser collecting *Cs. melanura*

Blood meal analysis using PCR

2. Extract DNA



Blood meal analysis using PCR

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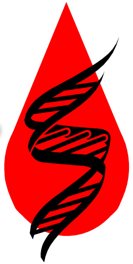
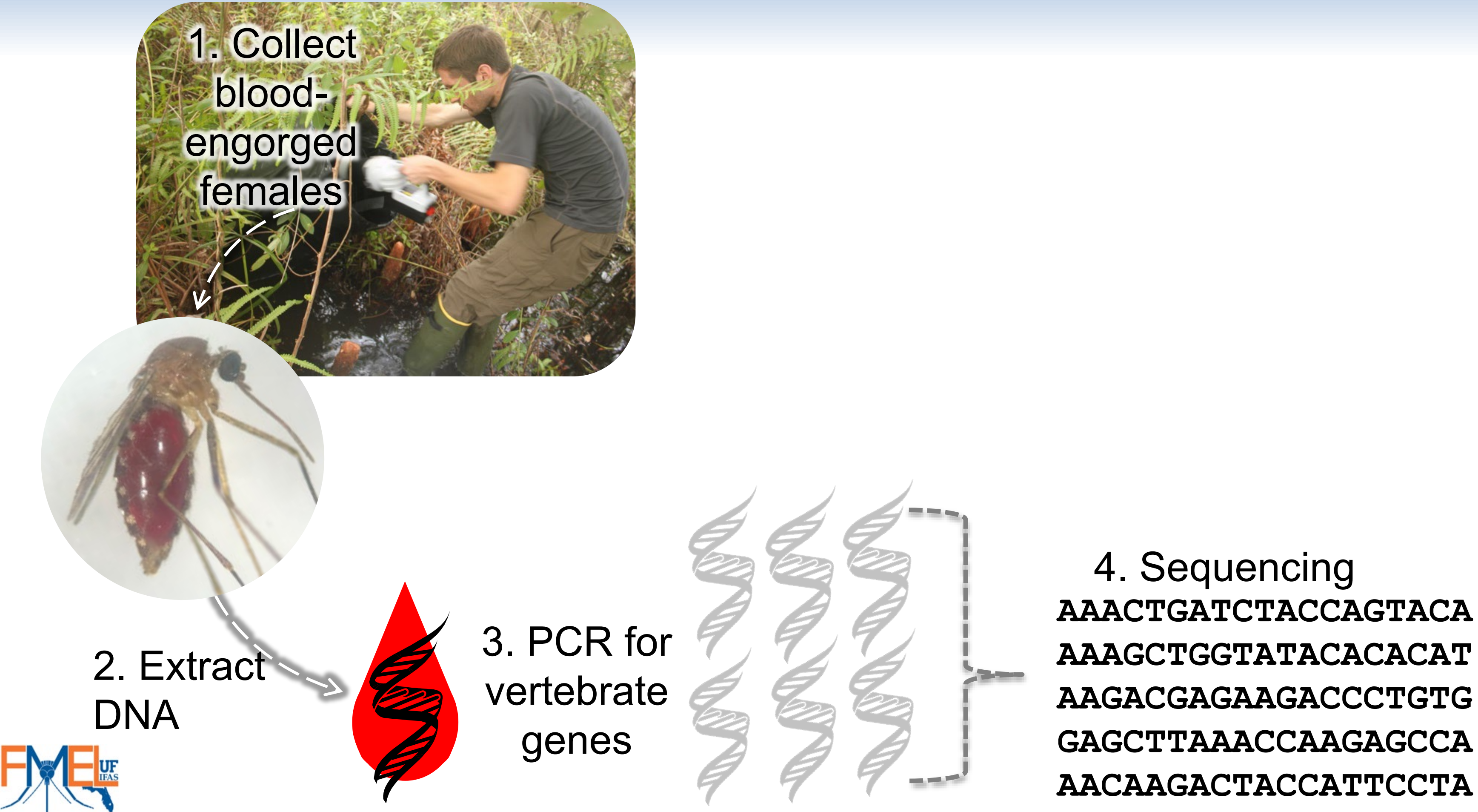


3. PCR for vertebrate genes

Blood meal analysis using PCR



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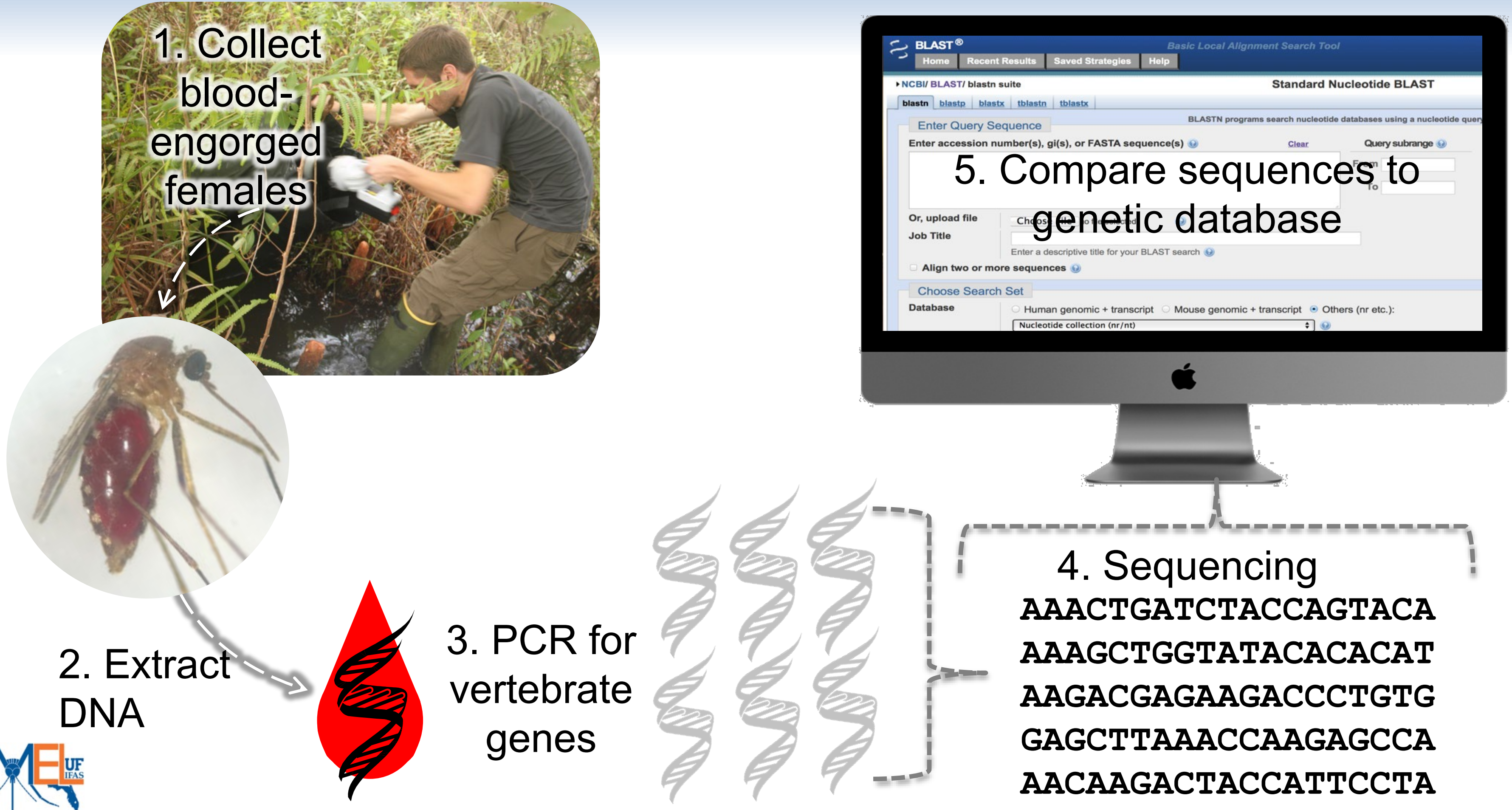
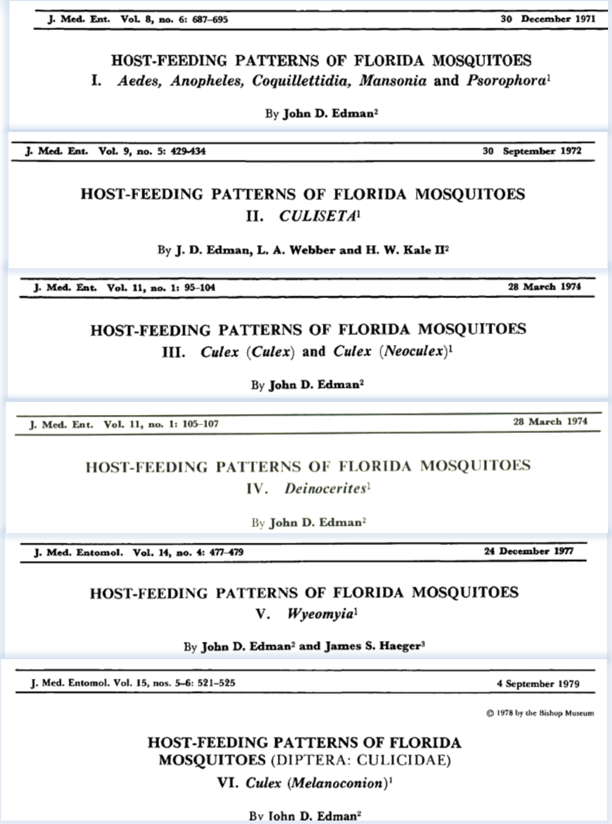


John D. Edman (and coauthors) using serological methods



J. Med. Ent. Vol. 8, no. 6: 687–695 30 December 1971

HOST-FEEDING PATTERNS OF FLORIDA MOSQUITOES
I. *Aedes, Anopheles, Coquillettidia, Mansonia* and *Psorophora*[1]

By John D. Edman[2]

J. Med. Ent. Vol. 9, no. 5: 429-434 30 September 1972

HOST-FEEDING PATTERNS OF FLORIDA MOSQUITOES
II. *CULISETA*[1]

By J. D. Edman, L. A. Webber and H. W. Kale II[2]

J. Med. Ent. Vol. 11, no. 1: 95–104 28 March 1974

HOST-FEEDING PATTERNS OF FLORIDA MOSQUITOES
III. *Culex* (*Culex*) and *Culex* (*Neoculex*)[1]

By John D. Edman[2]

J. Med. Ent. Vol. 11, no. 1: 105–107 28 March 1974

HOST-FEEDING PATTERNS OF FLORIDA MOSQUITOES
IV. *Deinocerites*[1]

By John D. Edman[2]

J. Med. Entomol. Vol. 14, no. 4: 477–479 24 December 1977

HOST-FEEDING PATTERNS OF FLORIDA MOSQUITOES
V. *Wyeomyia*[1]

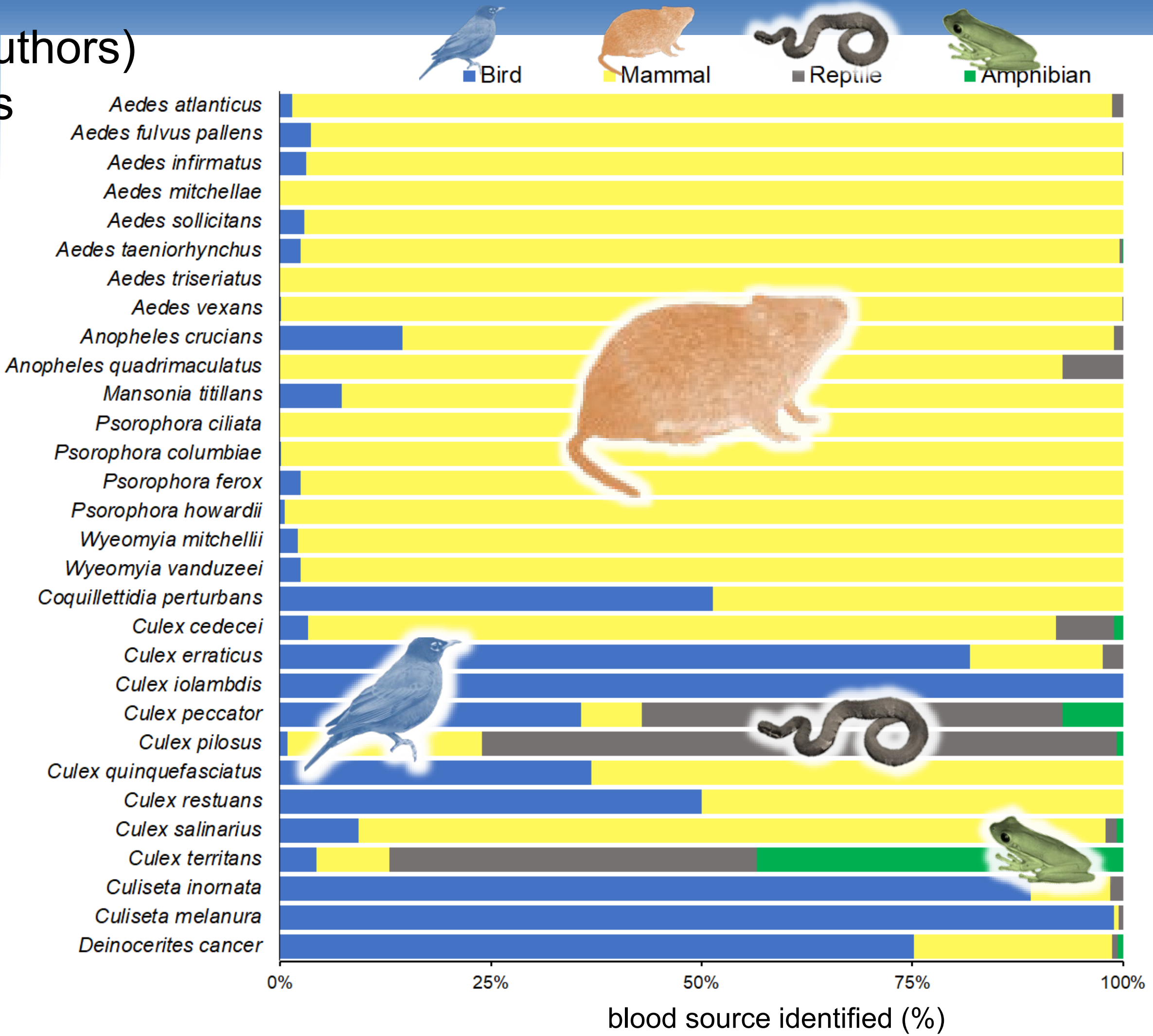
By John D. Edman[2] and James S. Haeger[3]

J. Med. Entomol. Vol. 15, nos. 5–6: 521–525 4 September 1979

© 1978 by the Bishop Museum

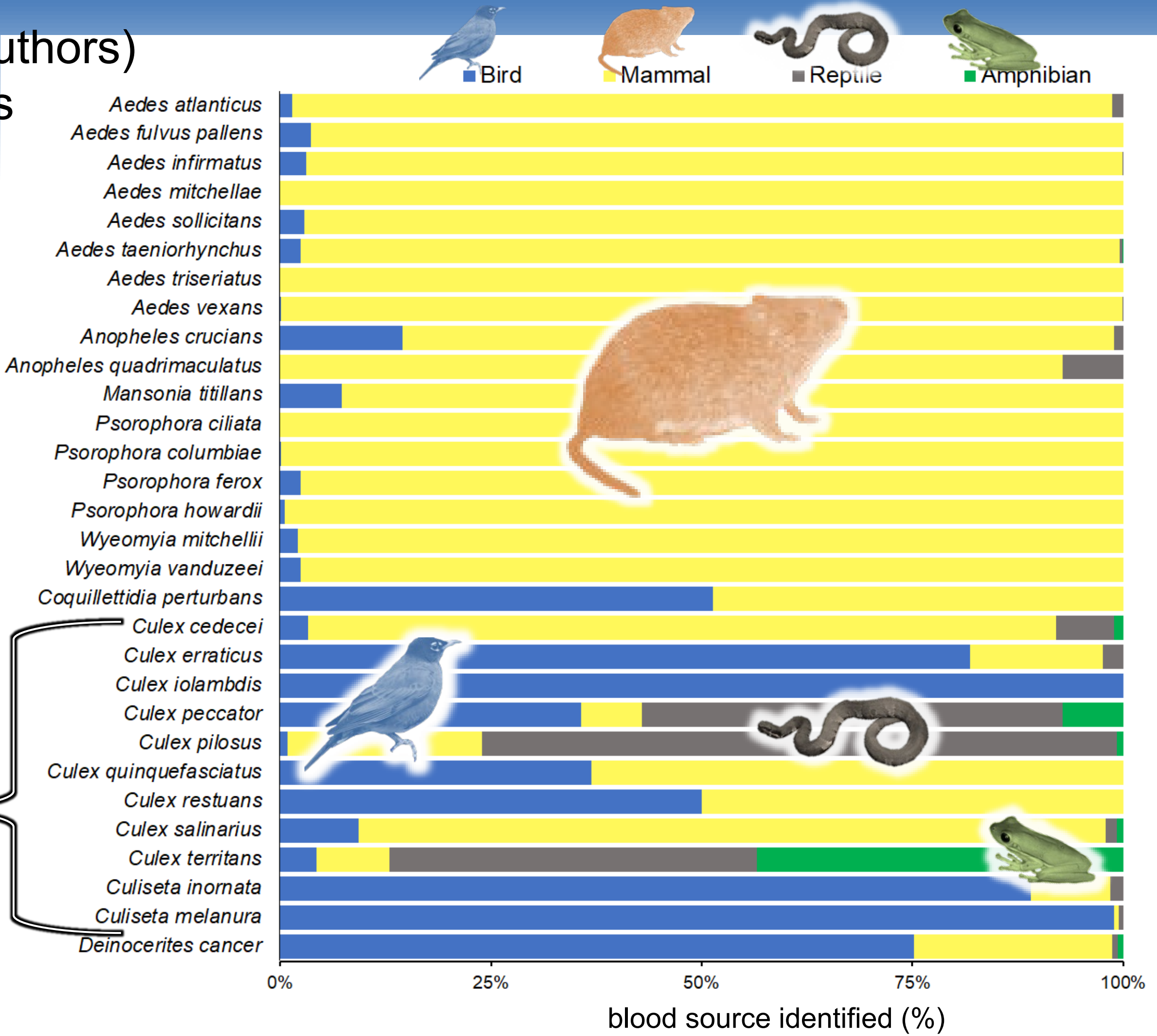
HOST-FEEDING PATTERNS OF FLORIDA MOSQUITOES (DIPTERA: CULICIDAE)
VI. *Culex* (*Melanoconion*)[1]

By John D. Edman[2]



John D. Edman (and coauthors) using serological methods

- *Culex & Culiseta* bite diverse vertebrates.
- This flexibility in host use may determine the local infection prevalence.



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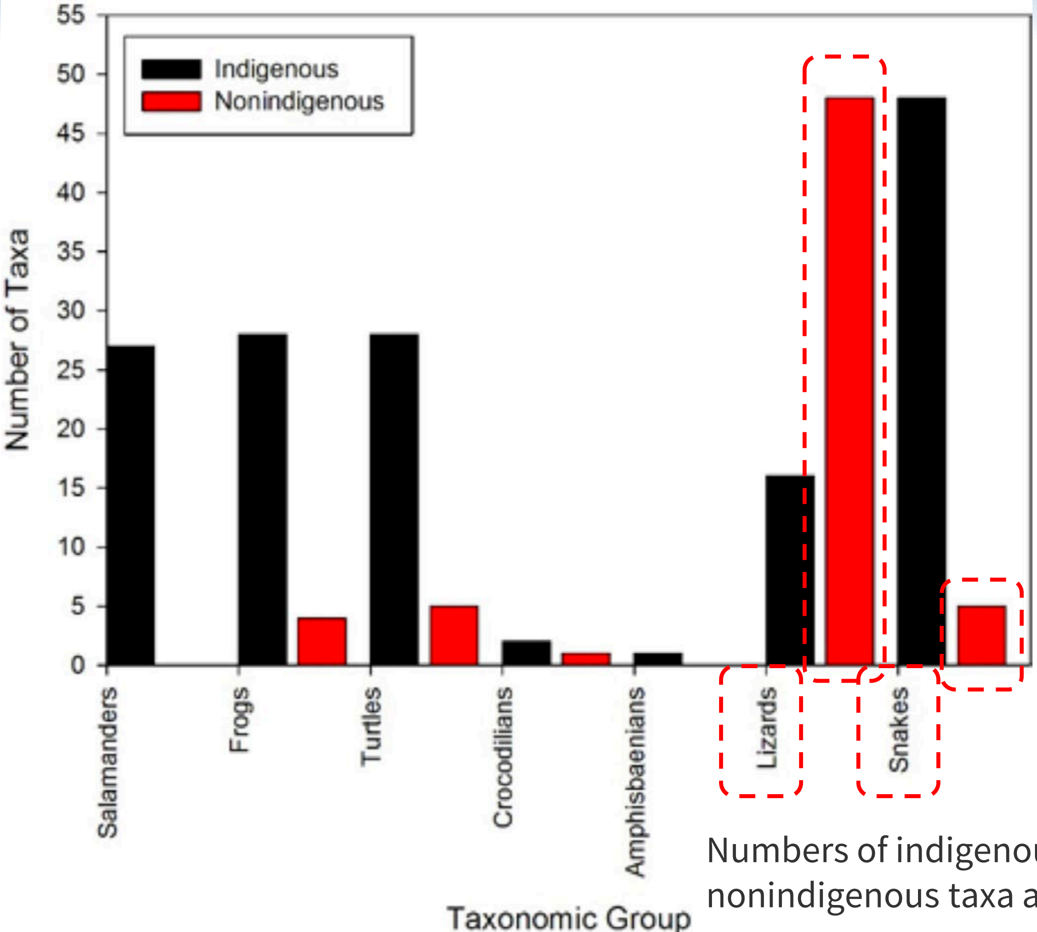
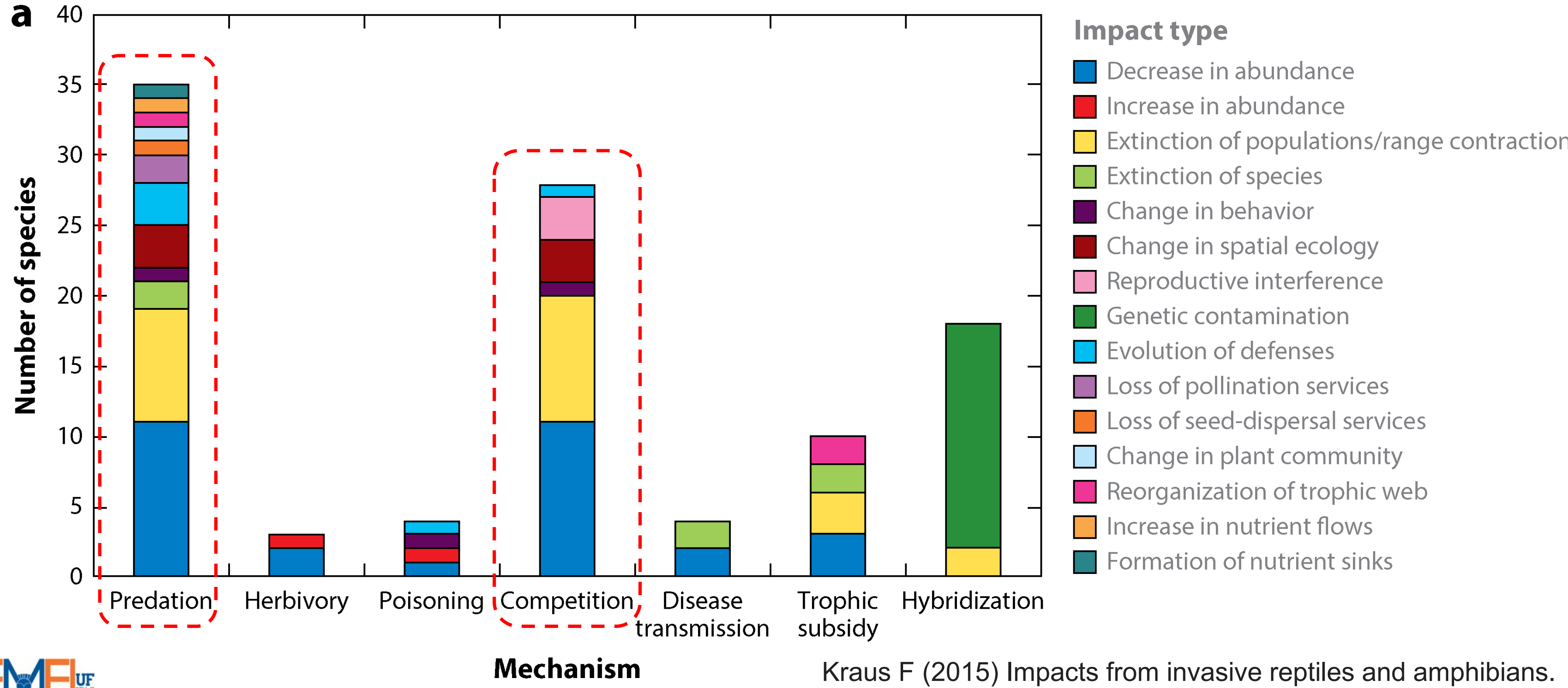
Krysko et al. (2016) New Verified Nonindigenous Amphibians and Reptiles in Florida through 2015, with a Summary of More Than 152 Years of Introductions.



Numbers of indigenous and established nonindigenous taxa among taxonomic groups.

Impact types among invasive reptiles and amphibians: (*a*) relative importance of impact mechanisms and the types of impacts derived from them.



Kraus F (2015) Impacts from invasive reptiles and amphibians. Annual Review of Ecology, Evolution, and Systematics.

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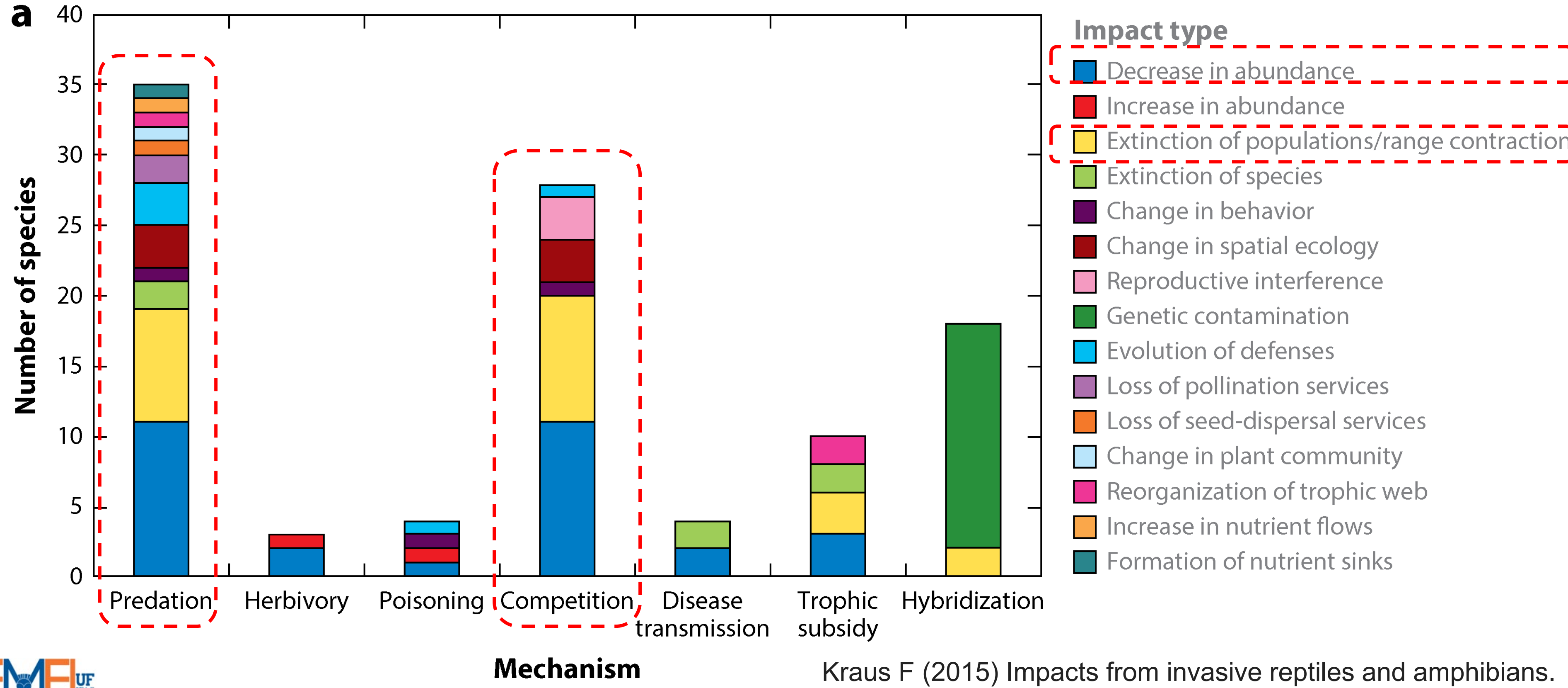

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Burmese python (*Python bivittatus*) is a large non-venomous snake native to South-east Asia, that has become established in South Florida through the exotic pet trade.

Photo by Lawrence Reeves

NAPLES, Fla. -- A group of Florida golfers found a new kind of adversar green in Naples over the weekend, CBS Miami reports: A large alligator an Burmese python entangled on the course. Richard Nadler posted the pictu his Facebook account while trying to play through the 10th hole at the Gol Fiddler's Creek.

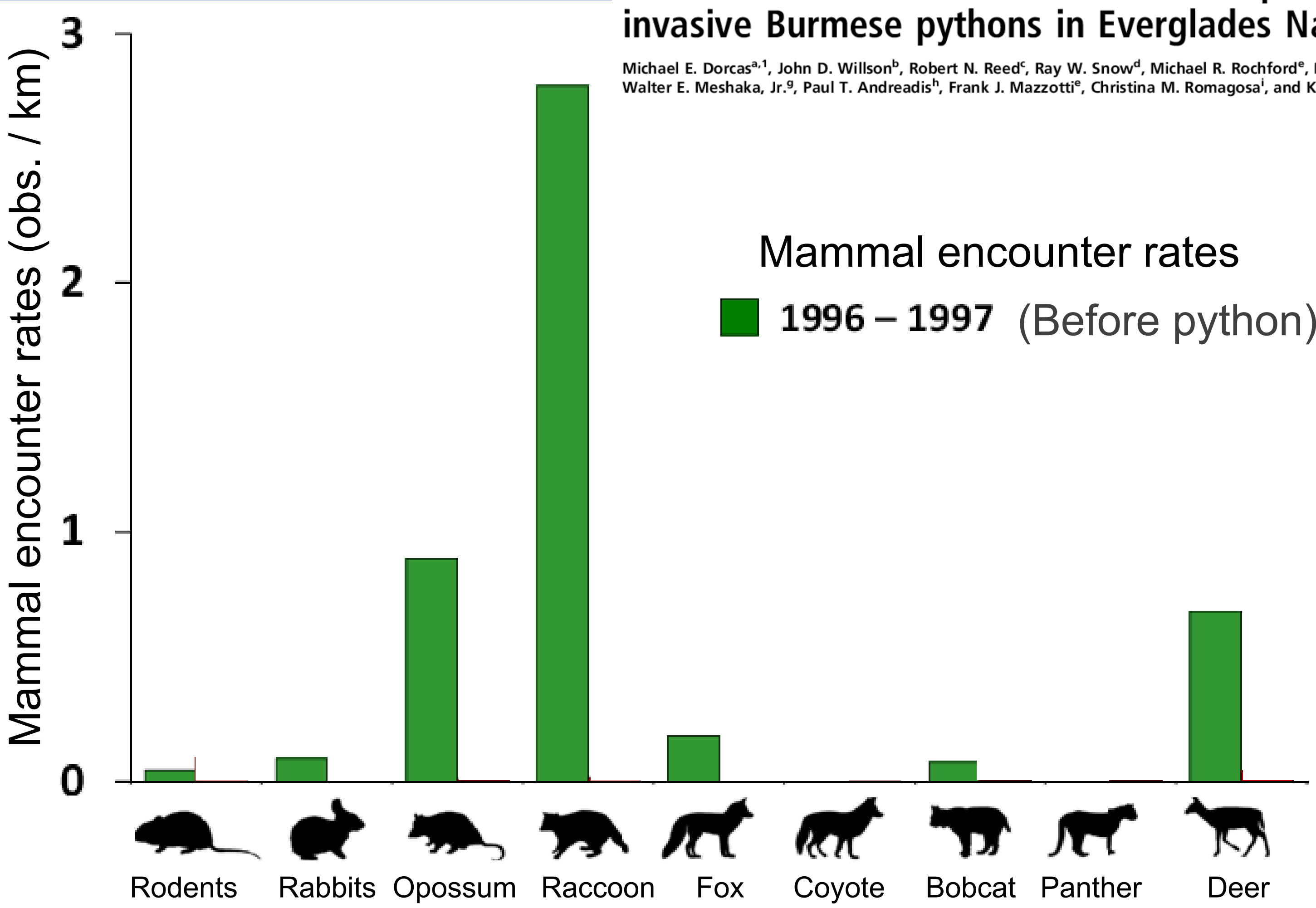
Richard Nadler
about a month ago

"Wild" day on the 10th hole today! That's a an alligator and a Burmese python entwined. The alligator seems to have the upper hand.


Conservancy of Southwest Florida
Florida Python Eats Deer Bigger Than Itself

Severe mammal declines coincide with proliferation of invasive Burmese pythons in Everglades National Park

Michael E. Dorcas[a,1], John D. Willson[b], Robert N. Reed[c], Ray W. Snow[d], Michael R. Rochford[e], Melissa A. Miller[f], Walter E. Meshaka, Jr.[g], Paul T. Andreadis[h], Frank J. Mazzotti[e], Christina M. Romagosa[i], and Kristen M. Hart[j]



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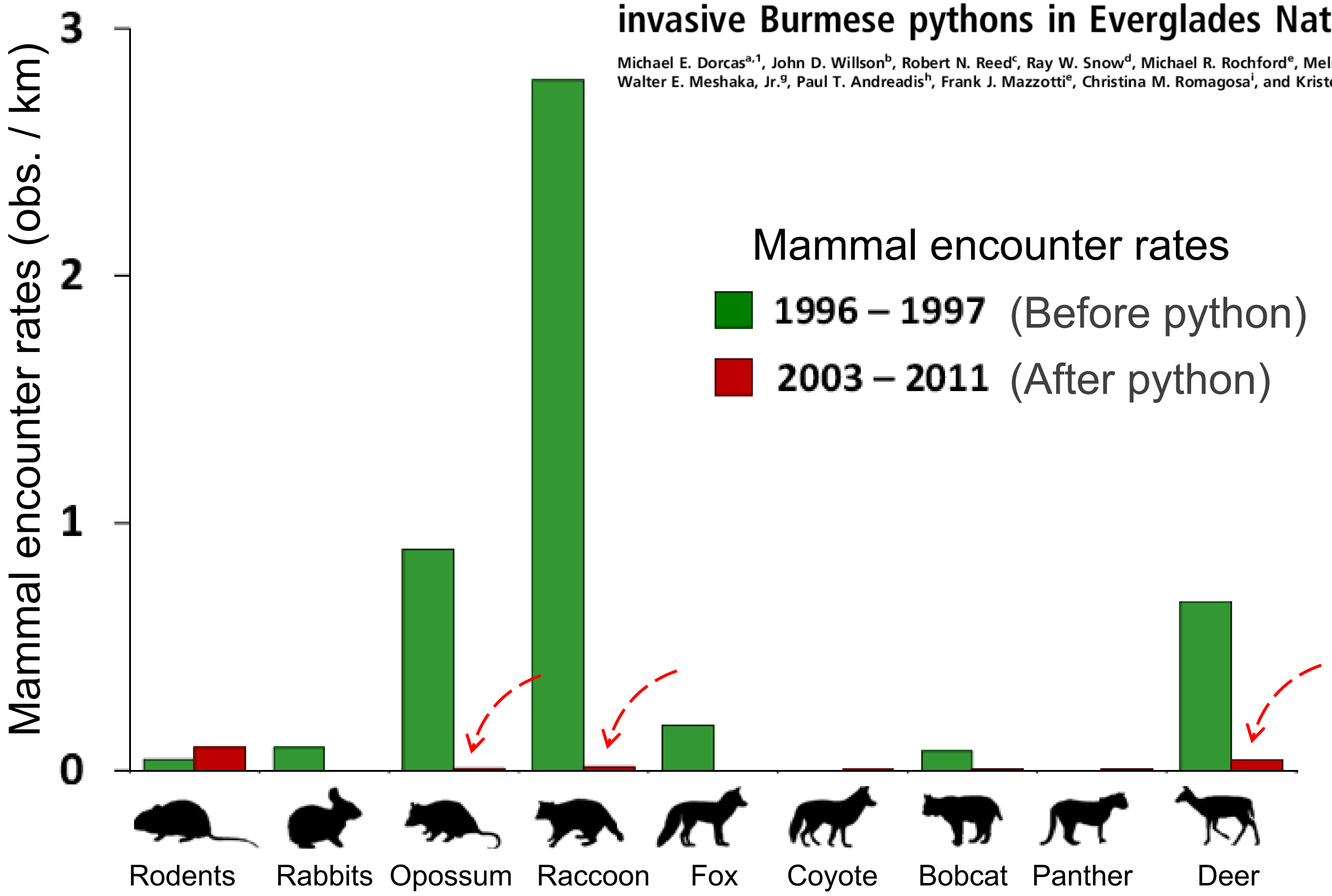

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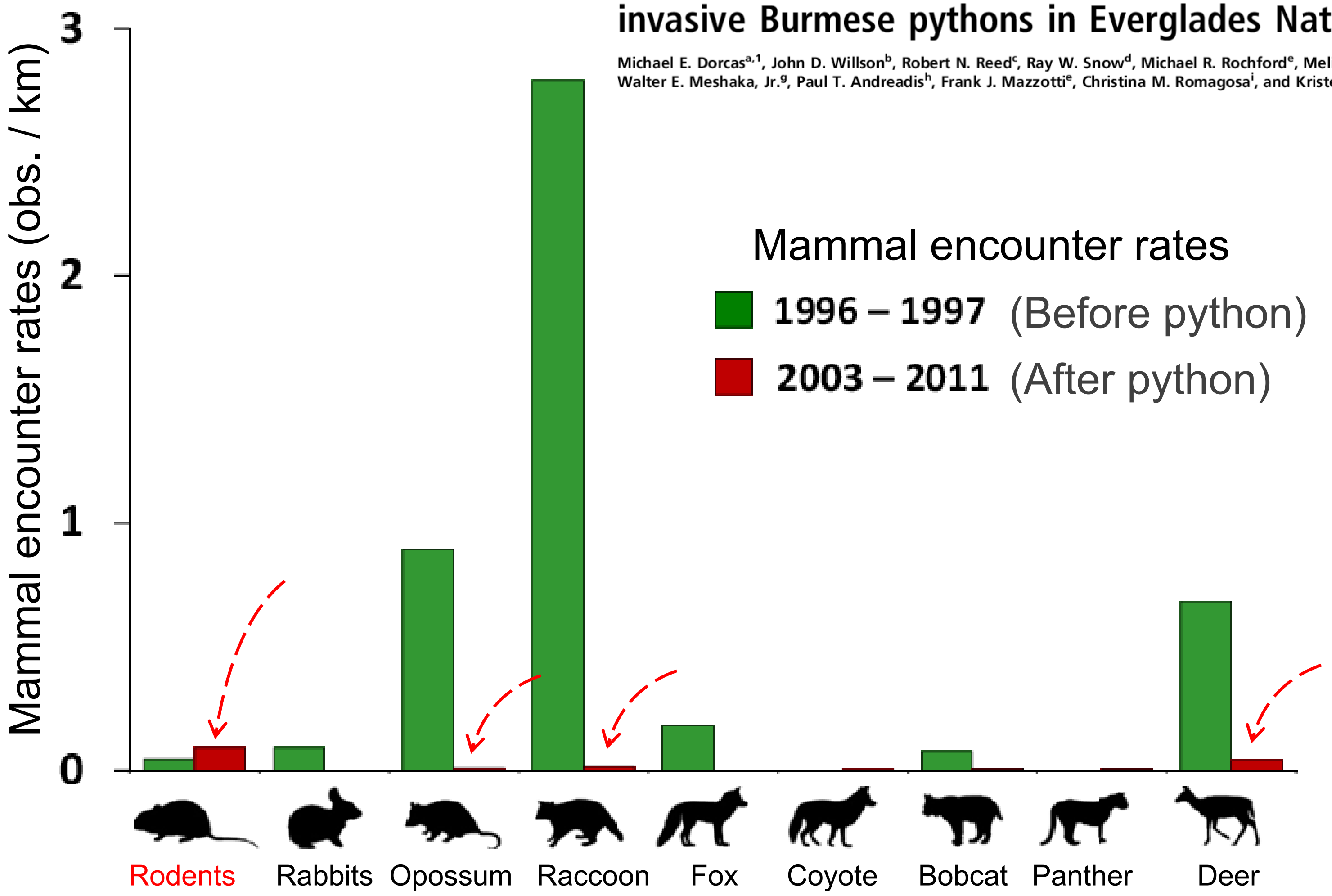
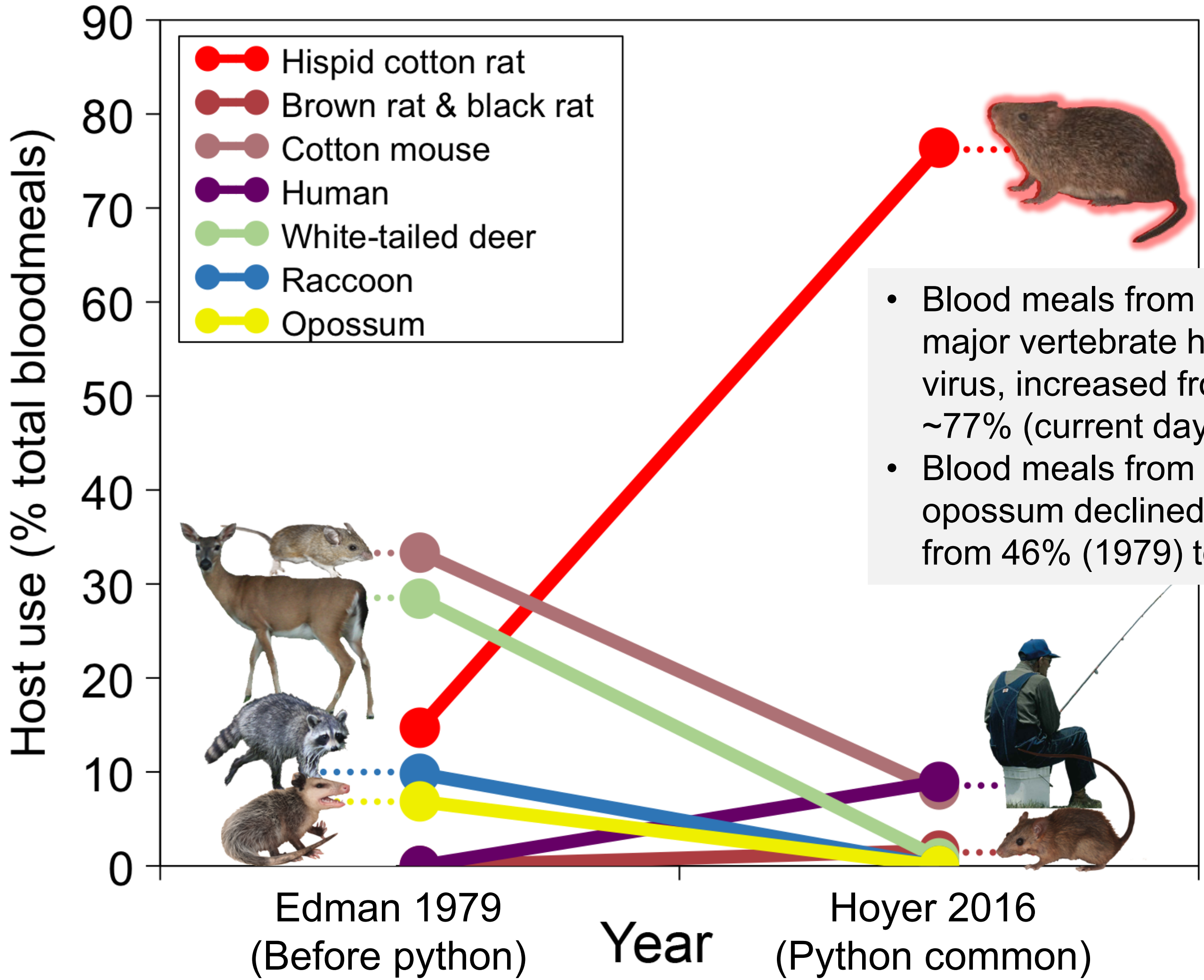
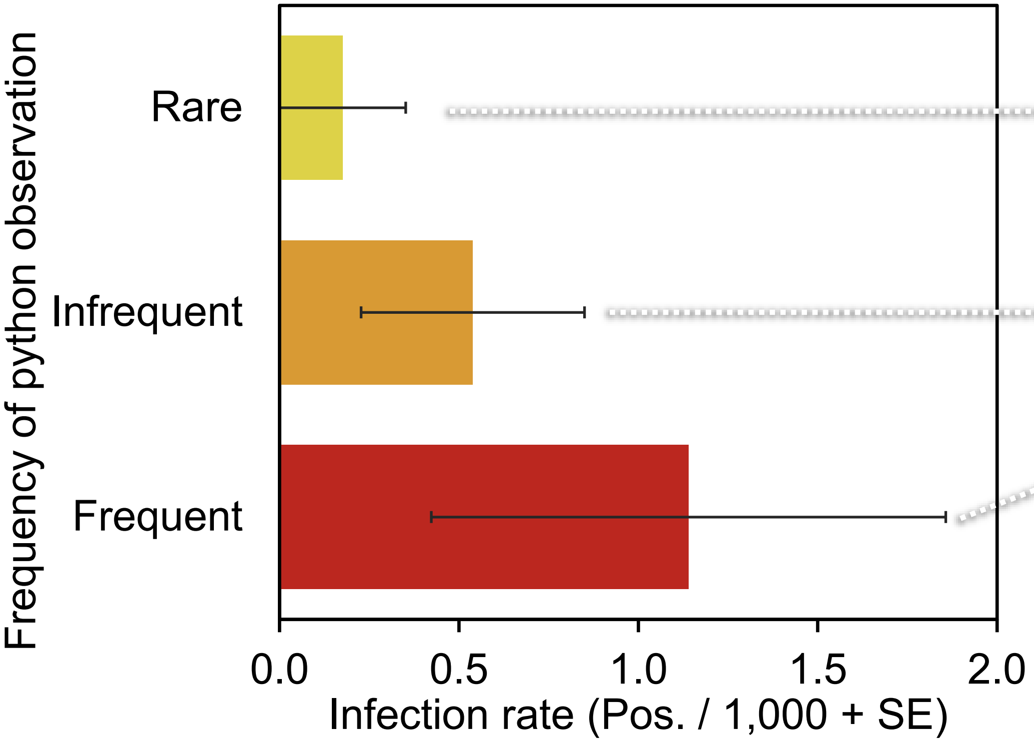


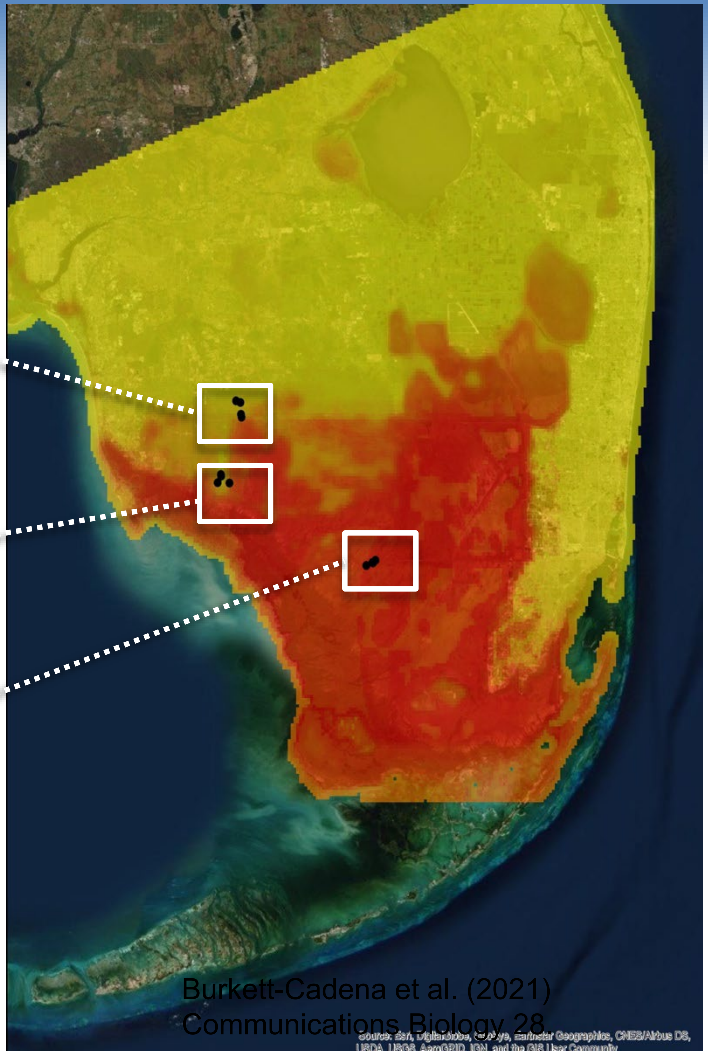


- Blood meals from hispid cotton rat, the major vertebrate host of Everglades virus, increased from ~15% (1979) to ~77% (current day).
- Blood meals from deer, raccoon and opossum declined over the same period, from 46% (1979) to <1% (current day).

Hoyer, Blosser, Acevedo, Thompson, Reeves, and Burkett-Cadena (2017) *Biology Letters*

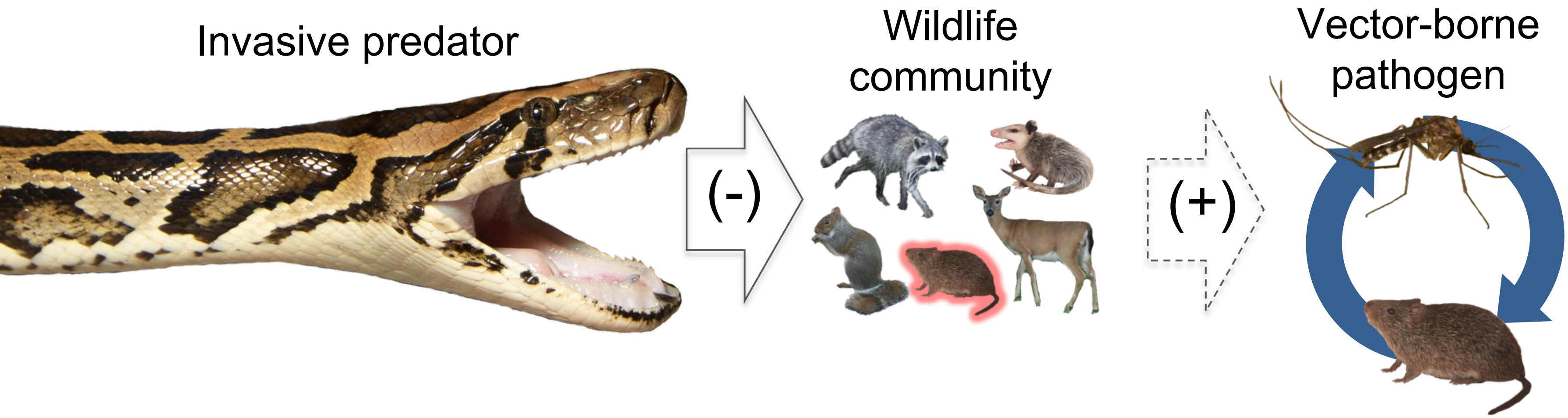
Everglades virus infection rate in vector was greatest in areas where pythons are frequently observed (10X higher than areas where pythons are rare)





Burkett-Cadena et al. (2021) Communications Biology 28

Burmese python and Everglades virus



- A greater fraction of vector blood meals are derived from the natural host of Everglades virus.
- The negative impact of the Burmese python on the mammal community may increase Everglades virus infection rates in the vector.

Two invasive lizards that (theoretically) impact mosquito-borne virus transmission in very different ways

Anolis sagrei, the brown anole

- Native to Caribbean islands
- First reported in Florida in 1887
- Has spread to every Florida county
- May be the most common lizard in Florida

Agama picticauda, Peters's rock agama

- Native to Africa
- More recently established in Florida in (1976)
- Currently expanding rapidly in Florida
- Is displacing the brown anole

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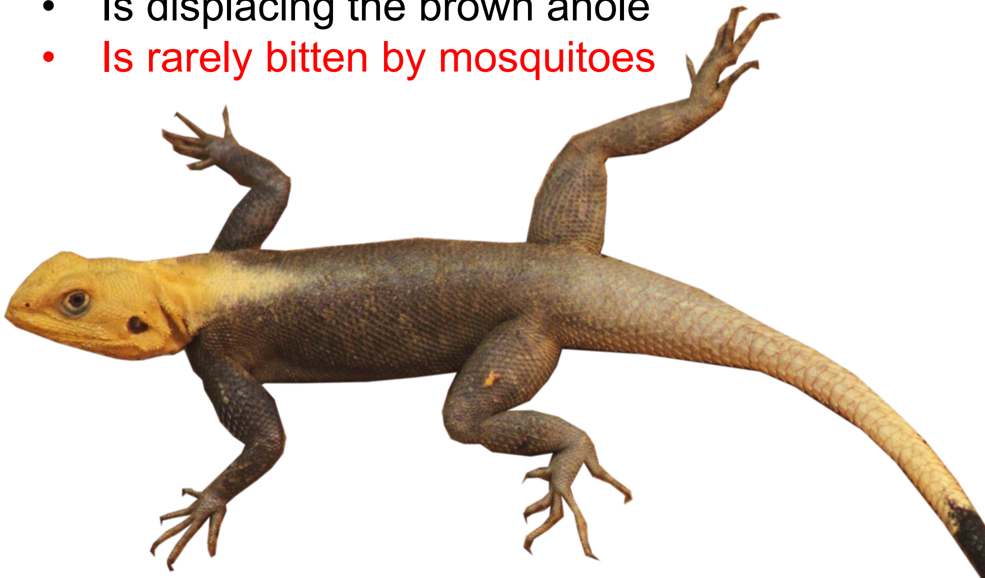
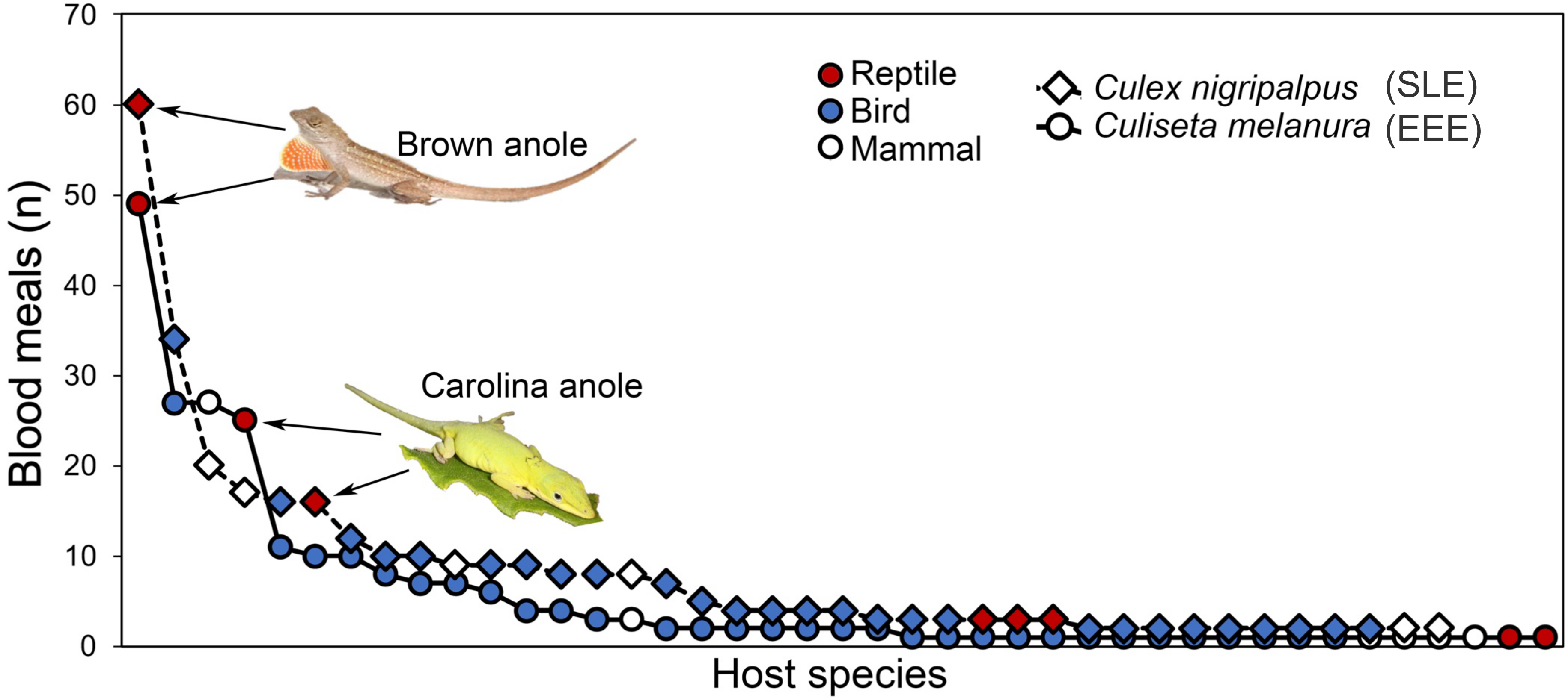
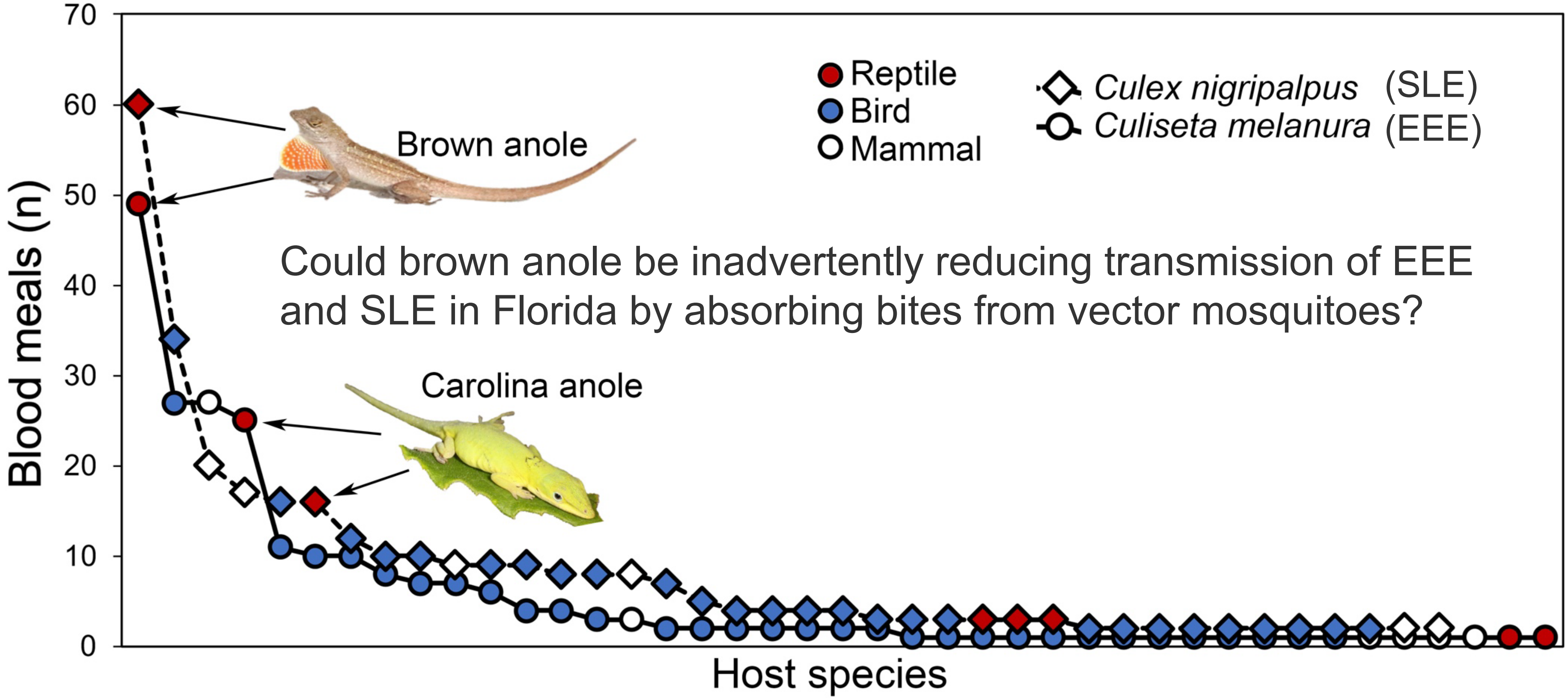


Blood meal analysis of vector mosquitoes in Florida, USA.



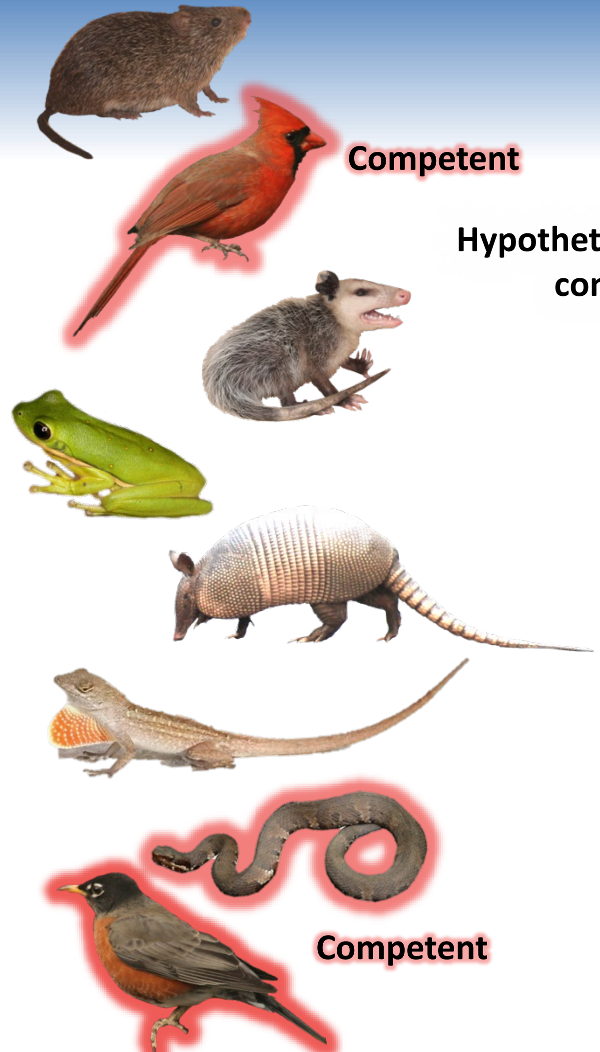
Data from Reeves and Burkett-Cadena (2022) and West et al. (2020).

Blood meal analysis of vector mosquitoes in Florida, USA.

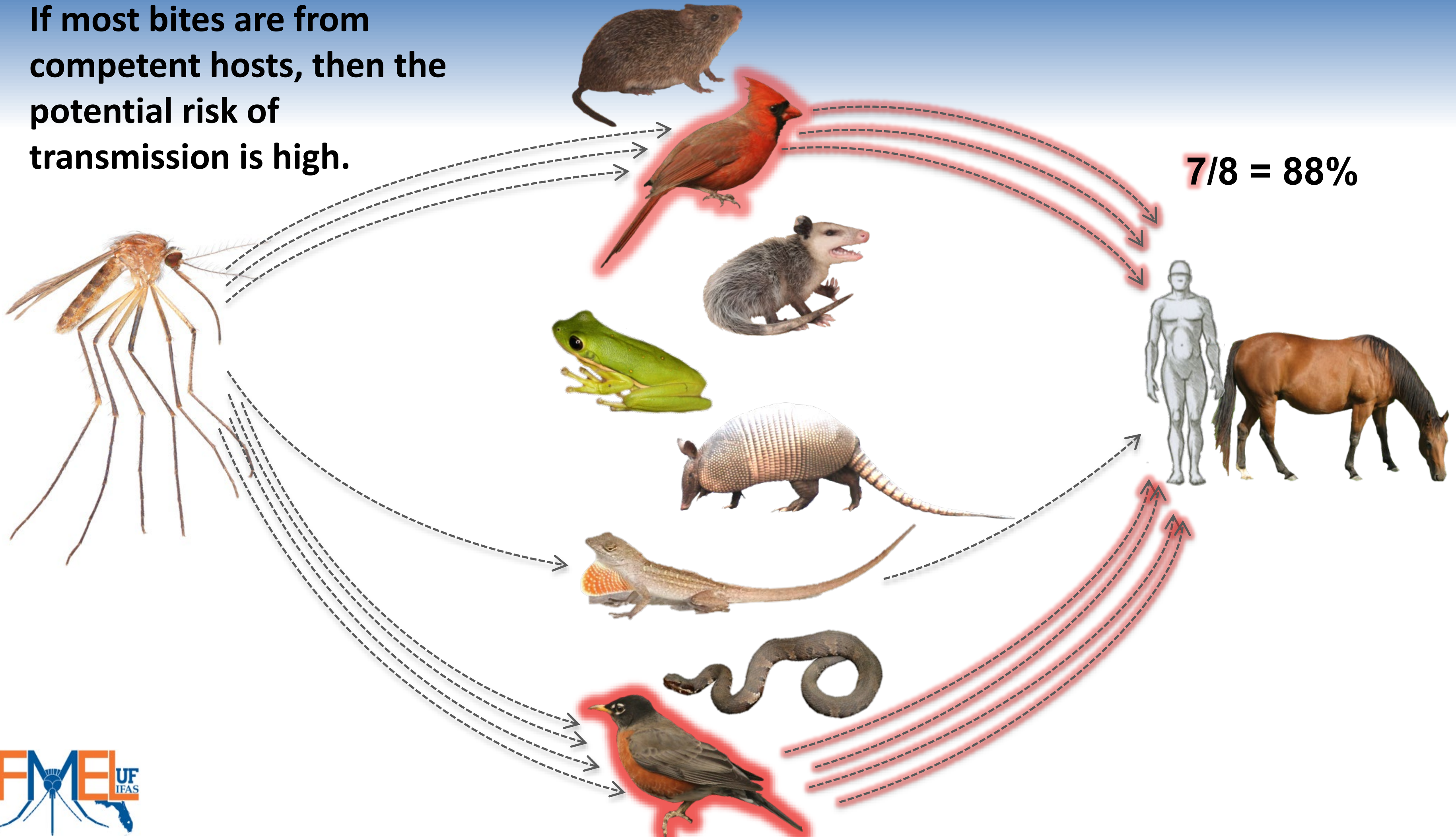


Data from Reeves and Burkett-Cadena (2022) and West et al. (2020).

Hypothetical host community

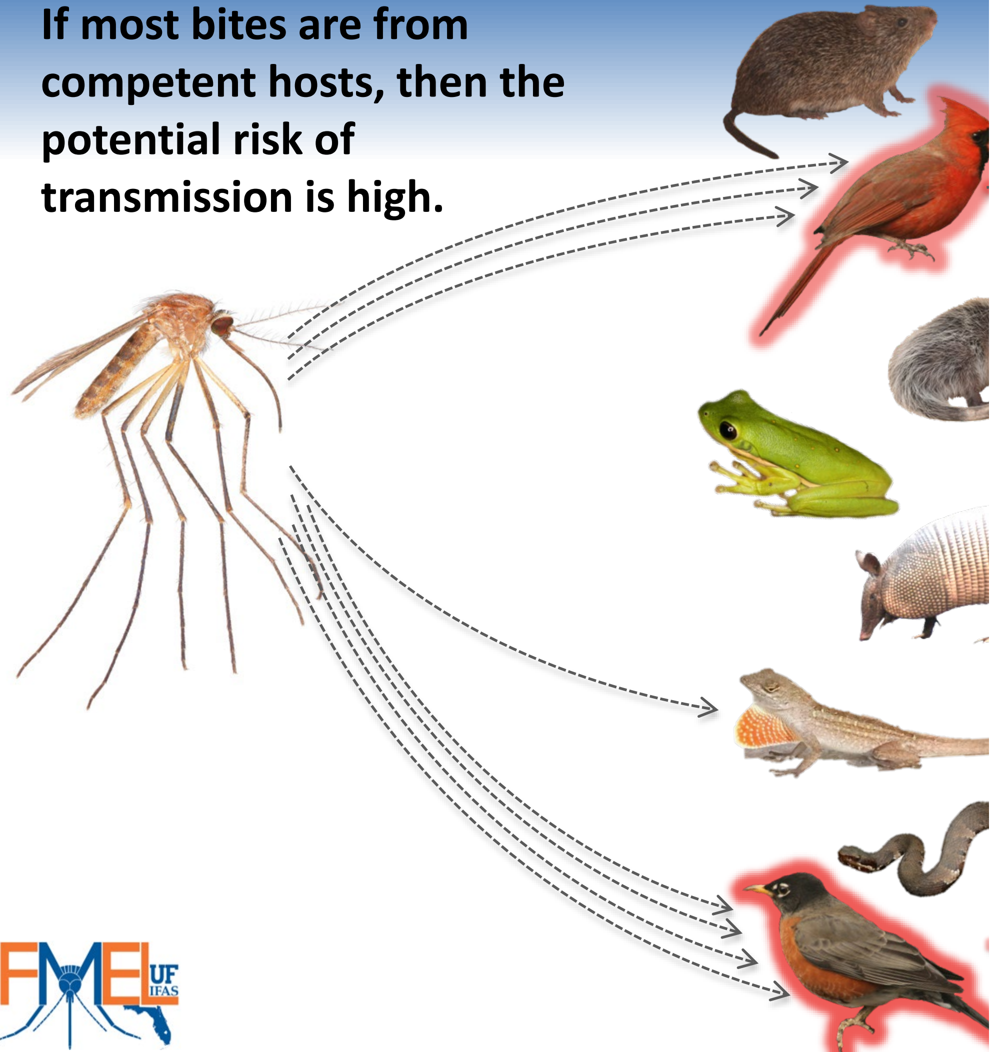


If most bites are from competent hosts, then the potential risk of transmission is high.



7/8 = 88%

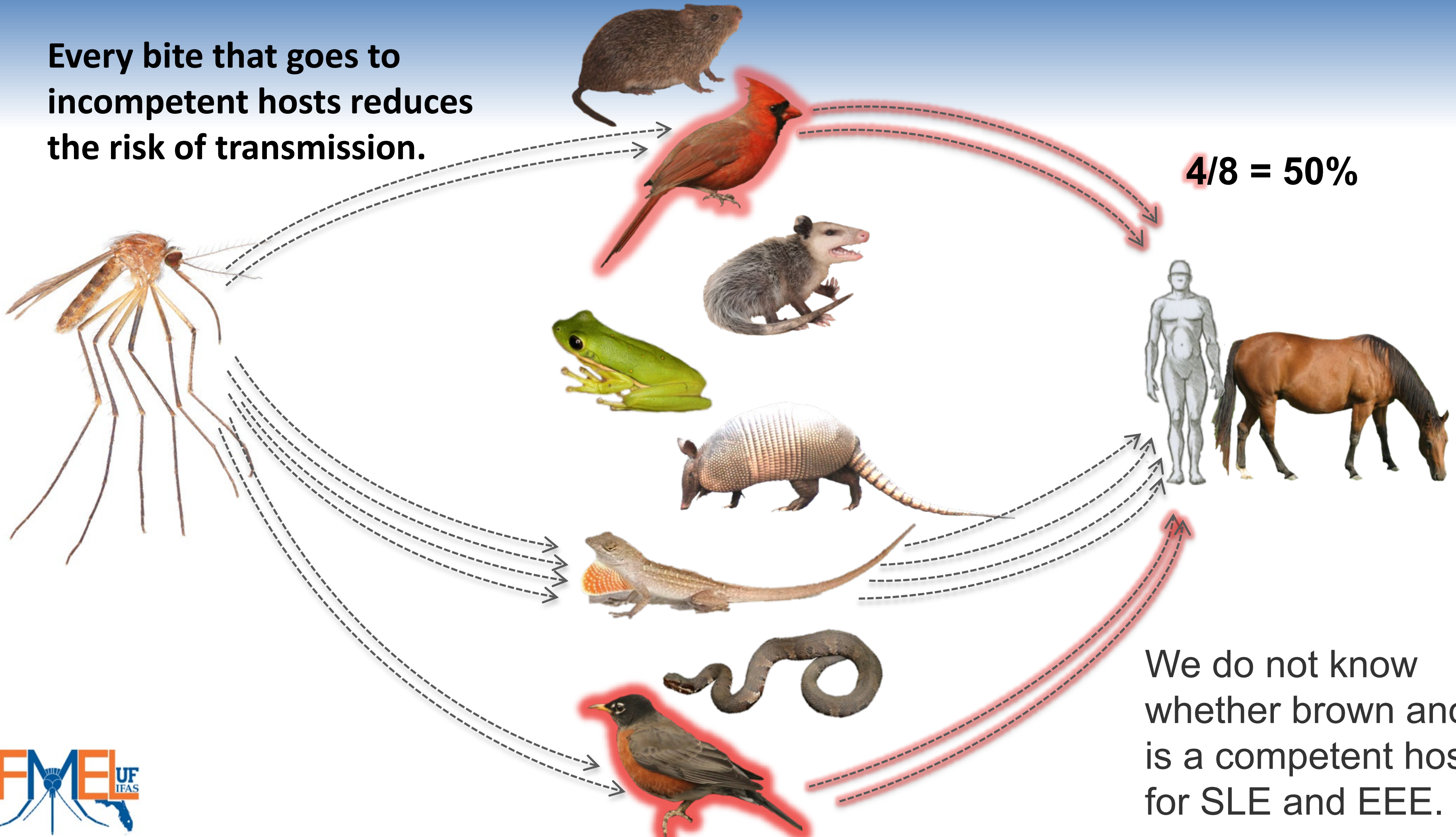
If most bites are from competent hosts, then the potential risk of transmission is high.



Edman (1972)

Host blood source	*Culiseta melanura*			
	Vero Beach			Tampa
	Resting box collections	Aspirator collections		Light trap collections
Passeriform	621	211	(79.2)*	32
Ciconiiform	119	28	(14.0)	2
Charadriiform	40	18	(5.5)	10
Piciform	4	–	(0.4)	–
Strigiform	3	–	(0.3)	–
Quail	3	–	(0.3)	2
Falconiform	2	–	(0.2)	–
Gruiform	1	–	(<0.1)	–
Pelecaniform	–	1	(<0.1)	–
Chicken	–	–		2
Unidentified	252	98		9
Total avian	1045	356		57
(%)	(98.8)	(99.2)		(96.6)
Ruminant	1	–		–
Rabbit	1	–		–
Muroid rodent	1	–		–
Unidentified	5	1		1
Total mammal	8	1		1
(%)	(0.7)	(0.3)		(1.7)
Snake	3	–		–
Lizard	1	–		–
Unidentified	1	2		1
Total reptile	5	2		1
(%)	(0.5)	(0.5)		(1.7)
Total no. reacting	1061**	359		59

Every bite that goes to incompetent hosts reduces the risk of transmission.

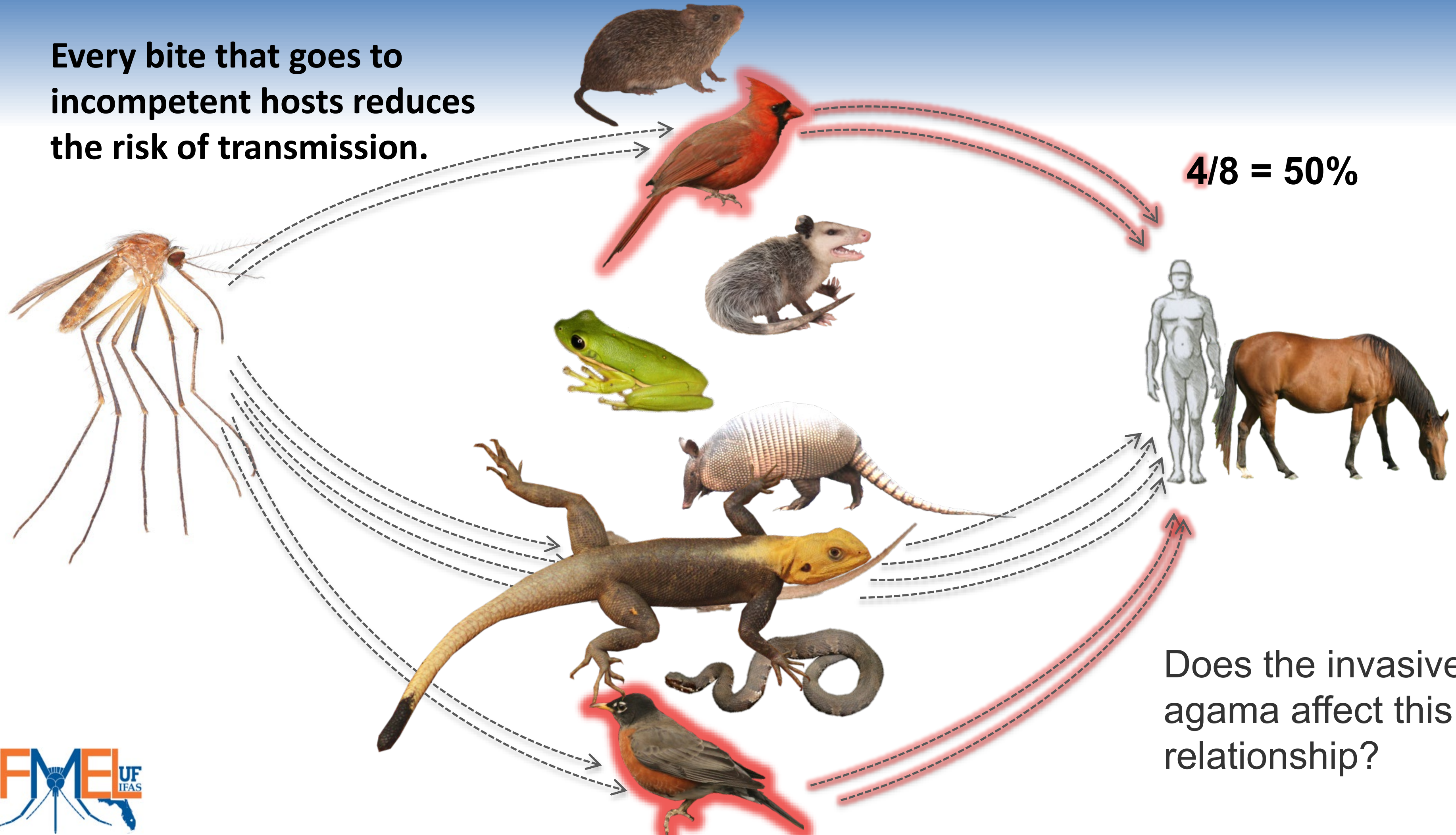


4/8 = 50%

We do not know whether brown anole is a competent host for SLE and EEE.

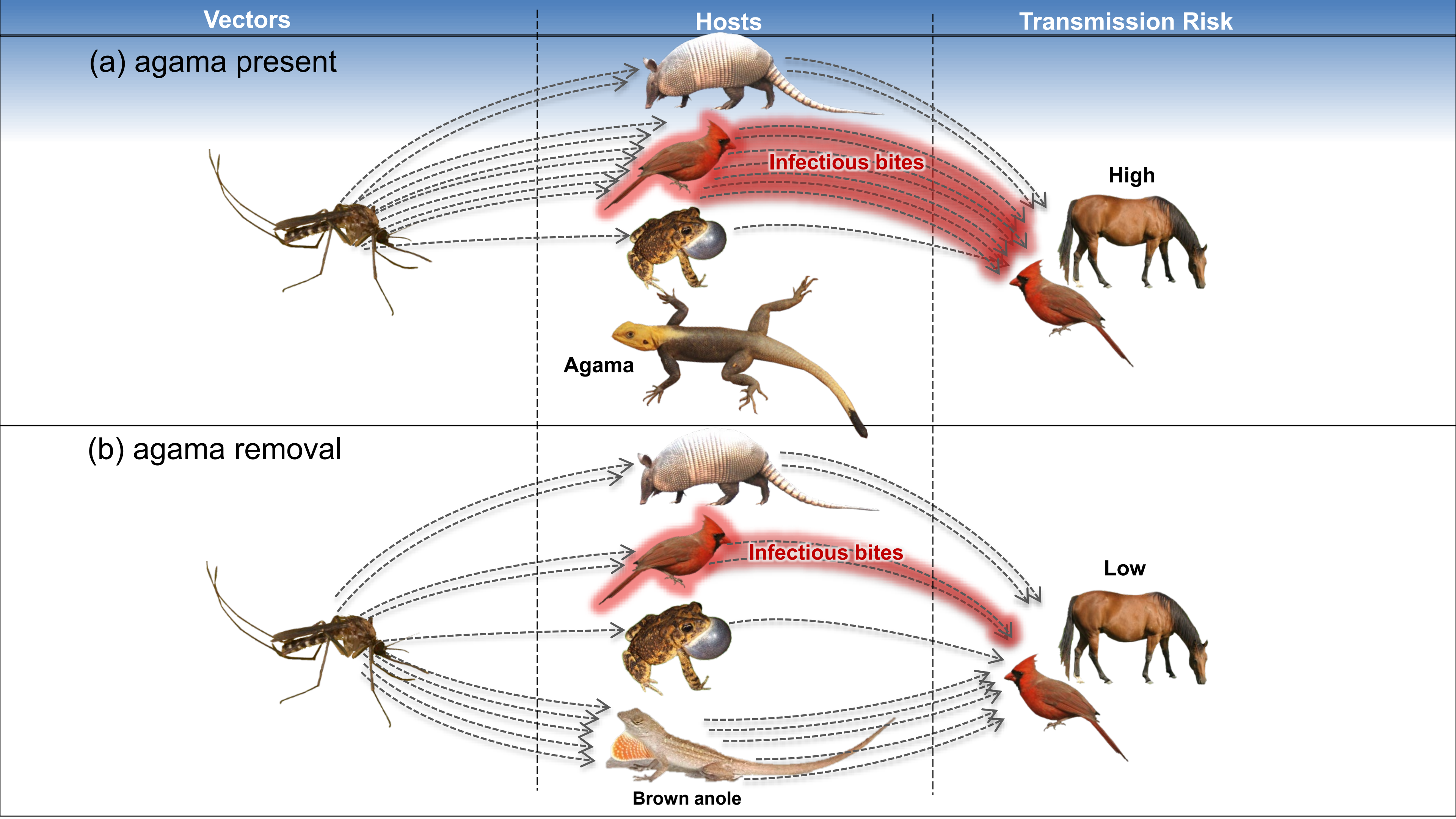
Every bite that goes to incompetent hosts reduces the risk of transmission.

4/8 = 50%



Does the invasive agama affect this relationship?

FMEL UF IFAS



Vectors
Hosts
Transmission Risk
(a) agama present
Infectious bites
High
Agama
(b) agama removal
Infectious bites
Low
Brown anole

Invasive reptiles and vector-borne pathogens

- Host use by mosquitoes has a strong affect on transmission of vector-borne pathogens.
- Some invasive reptiles are affecting patterns of host use (which animals are bitten) by vector mosquitoes.
- Some invasive reptiles (Burmese python) affect host use in a way that increases transmission risk.
- Other invasive reptiles (brown anole) may decrease transmission risk by absorbing vector bites.
- Any species that alters mosquito host use in a community, affects transmission risk.

Thank you

Erik Blosser
UF | FMEL

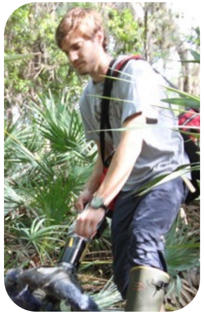
Lary Reeves
UF | FMEL

Annie Loggins
UF | WEC

Bob McCleery
UF | WEC

Melissa Miller
UF | FLREC

Lindsay
Campbell
UF | FMEL



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