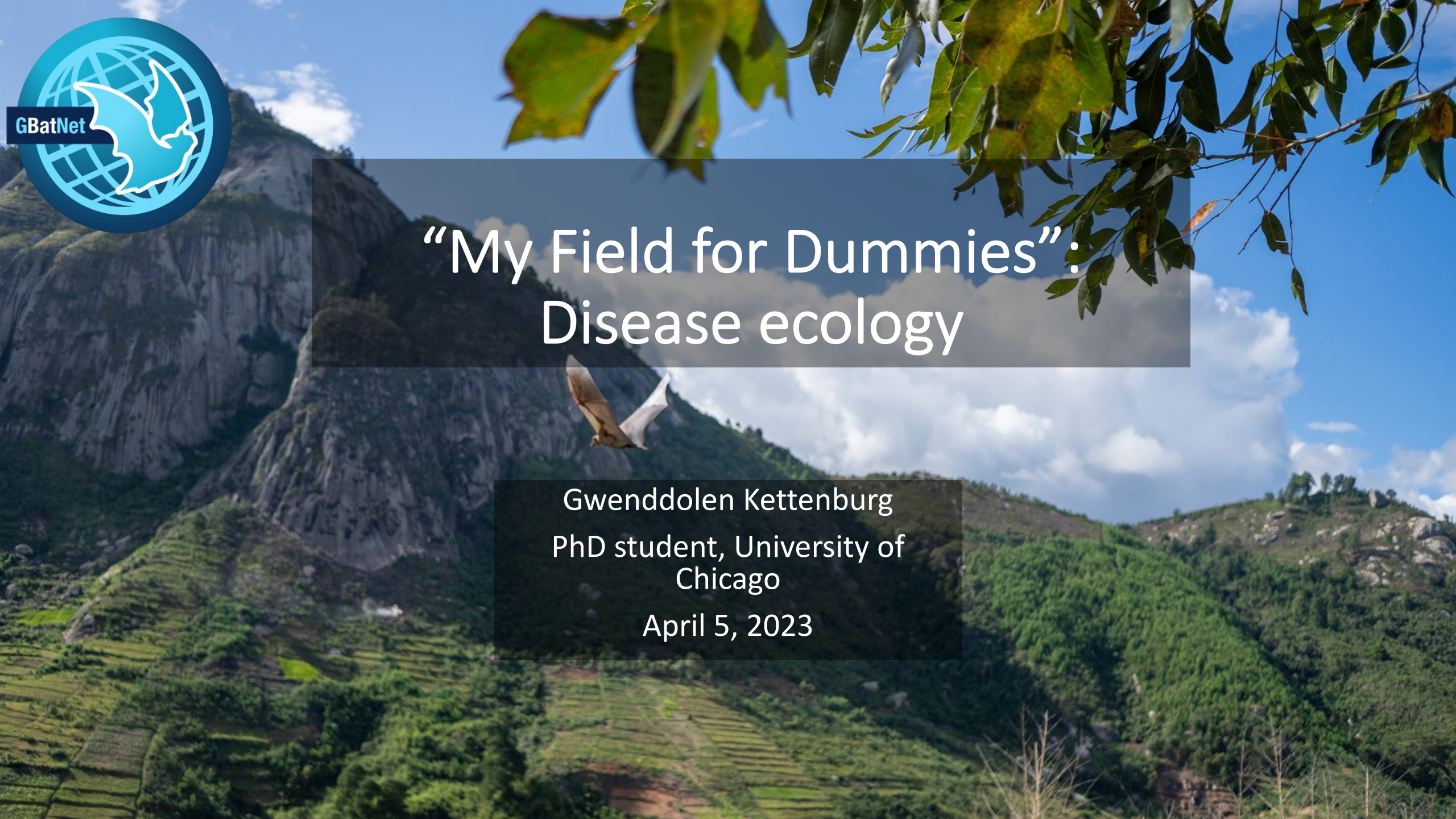


“My Field for Dummies”: Disease ecology

Gwenddolen Kettenburg

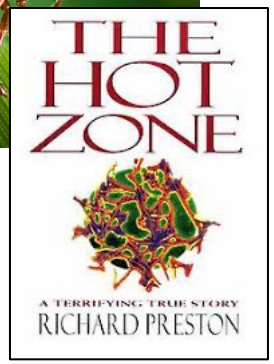
PhD student, University of Chicago

April 5, 2023

My path to disease ecology

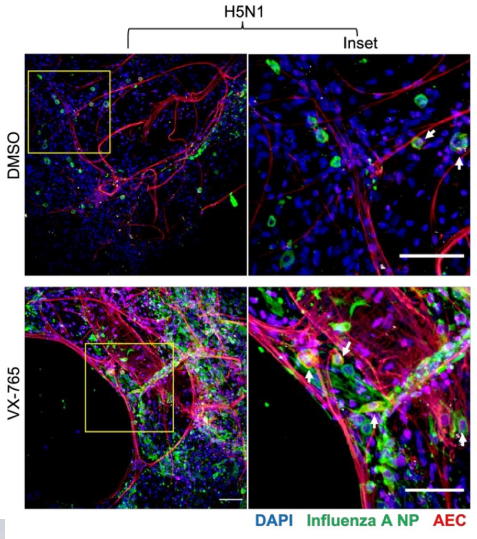
Undergraduate

Keystone College



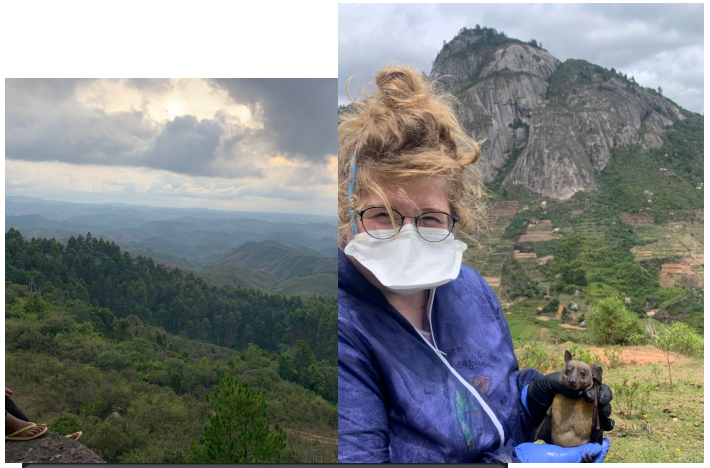
Master's

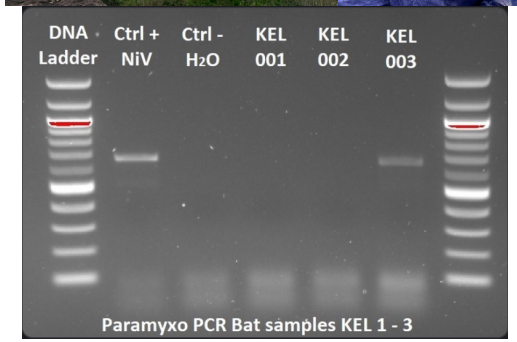
University of Pittsburgh



PhD student

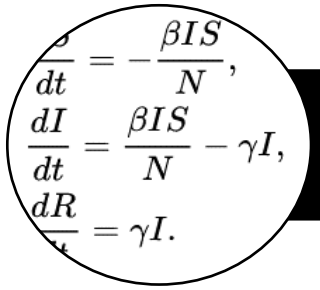
The University of Chicago 1890





Outline

What is ecology?



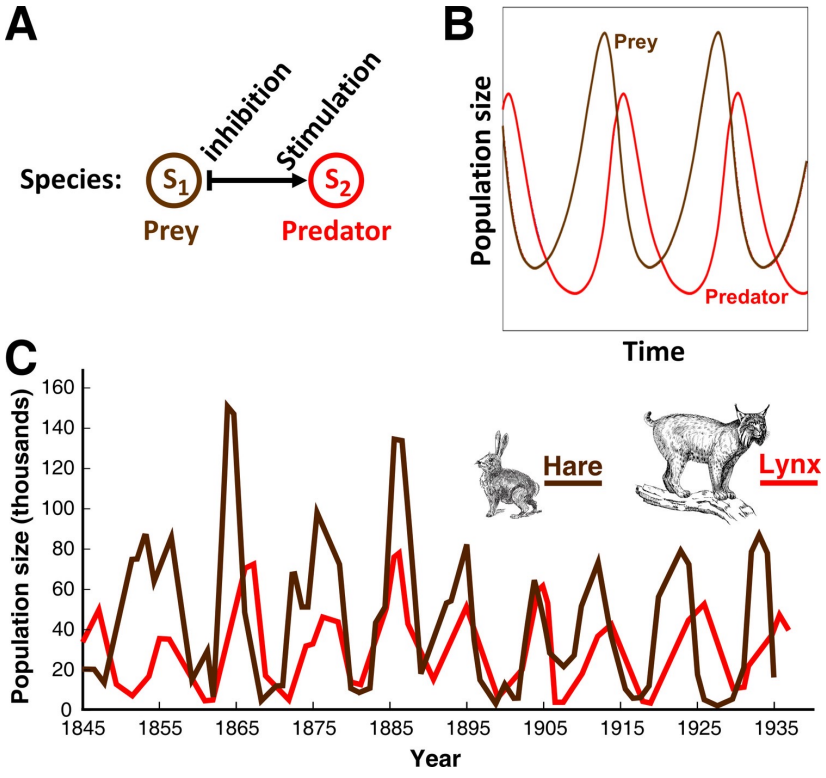
Science of disease ecology

Application to bat research

What is ecology?

Study of the interactions of organisms with each other and their environments

Ecology uses models to formalize general laws and principles describing the natural world

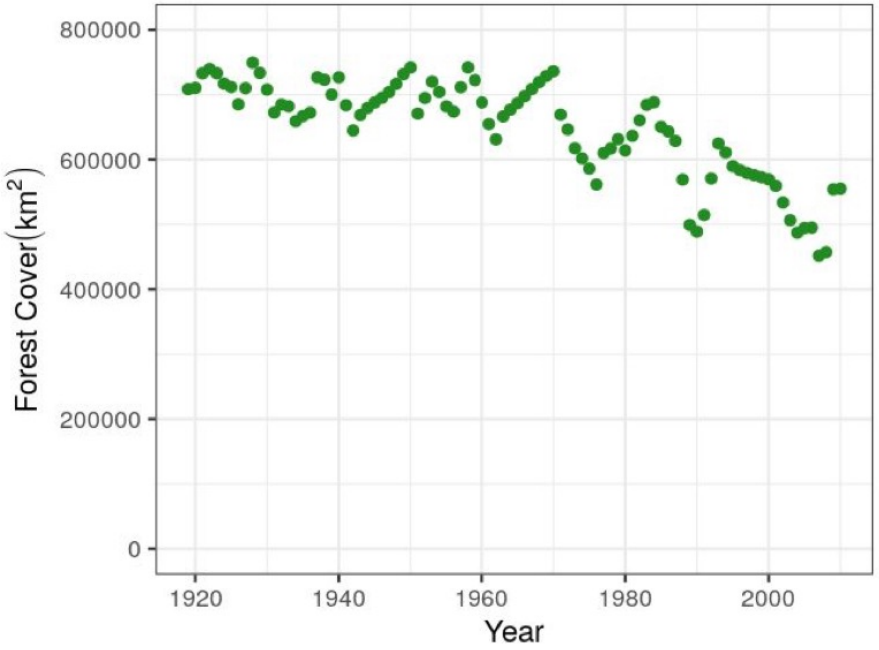


esa, 2016

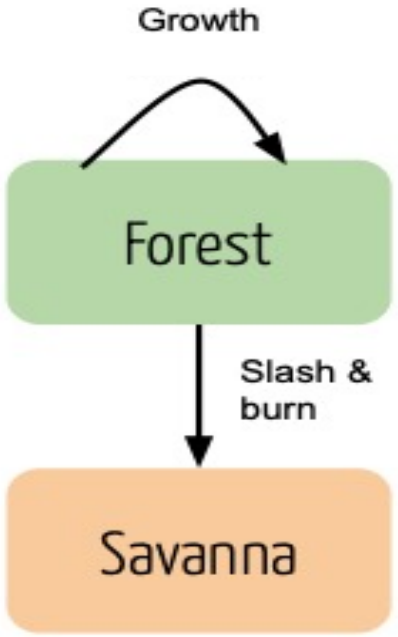
Momeni 2017

What is ecology?

Statistical models:
Pattern-driven



Mechanistic models:
Process-driven

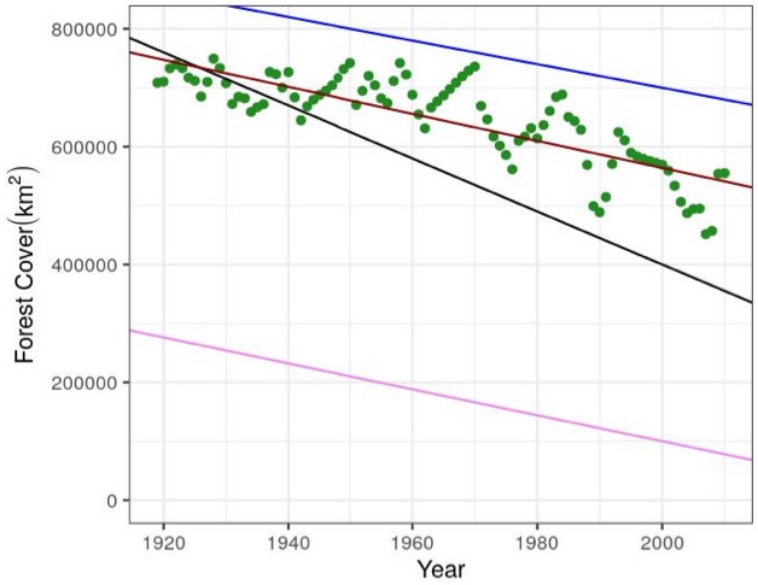


Ecological models can explain patterns or processes

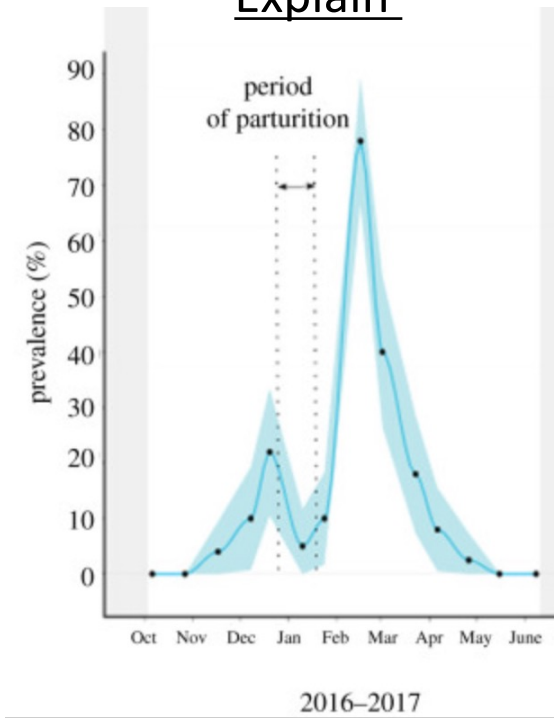
What is ecology?

Models explain and predict, producing simulated data that is comparable against observed data through model fitting

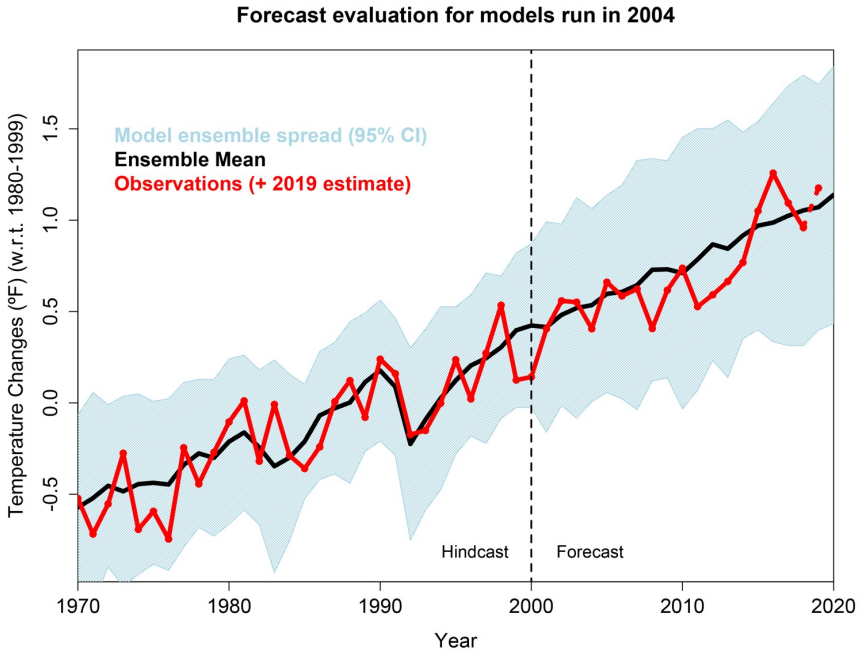
Fit model



Explain



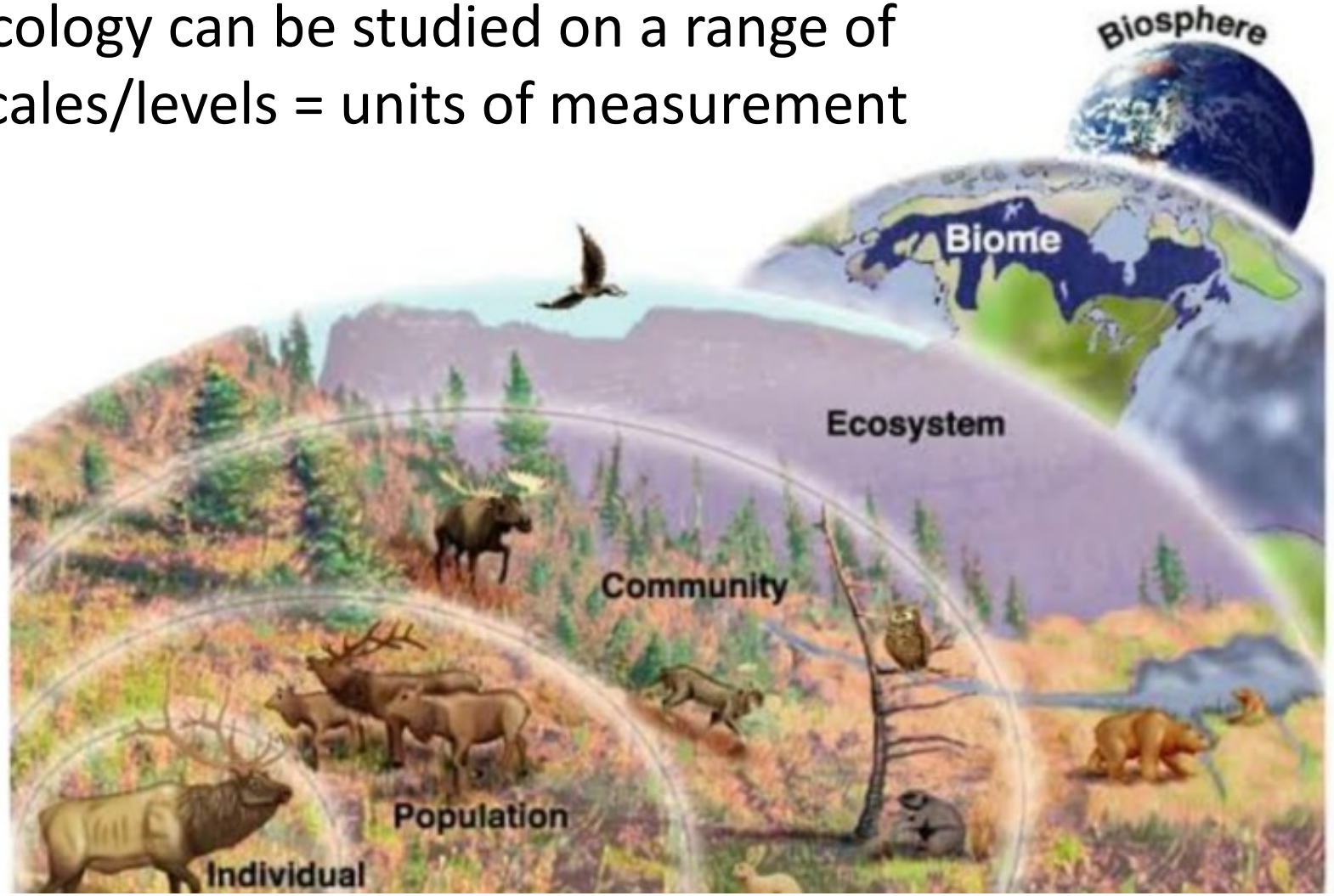
Predict

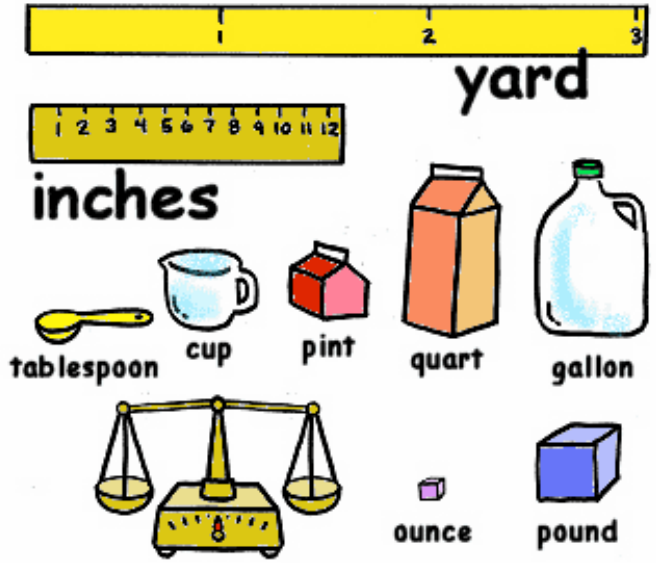


E2M2, 2022
Joffrin, 2022
Schmidt, 2000

What is ecology?

Ecology can be studied on a range of scales/levels = units of measurement





Google images

What is ecology?

Organisms are organized into different levels

Photo: Michael Durham

Individual level: we can study adaptations, and interactions with other single organisms

Example: how would this individual Mexican-free tailed bat adapt to climate change? How would this bat compete with another bat for food?

What is ecology?

Organisms are organized into different levels

Photo: TPWD

Population level: a group of organisms of the same species that live in the same area at the same time. Population ecologists study the size, density, and structure of populations and how they change over time.

Example: we can use population numbers to determine if a population is stable or changing

What is ecology?

Organisms are organized into different levels

Photo: TPWD

Photo: Google images

Photo: Google images

Photo: Google images

Community level: A biological community consists of all the populations of different species that live in a given area. Community ecologists focus on interactions between populations and how these interactions shape the community.

Example: When there are more moths for the bats to eat, does the bat population increase?

What is ecology?

Organisms are organized into different levels

Photo: Jonathon Alonzo

Ecosystem level: An ecosystem consists of all the organisms in an area, the community, and the abiotic factors that influence that community

Example: How does rainfall affect the populations of bats and moths around Bracken Cave?

What is ecology?

Organisms are organized into different levels

Photo: google images

Biosphere level: The biosphere is planet Earth, viewed as an ecological system. Ecologists working at the biosphere level may study global patterns—for example, climate or species distribution—interactions among ecosystems, and phenomena that affect the entire globe

Example: Climate change research

What is ecology?

Applications to bat research

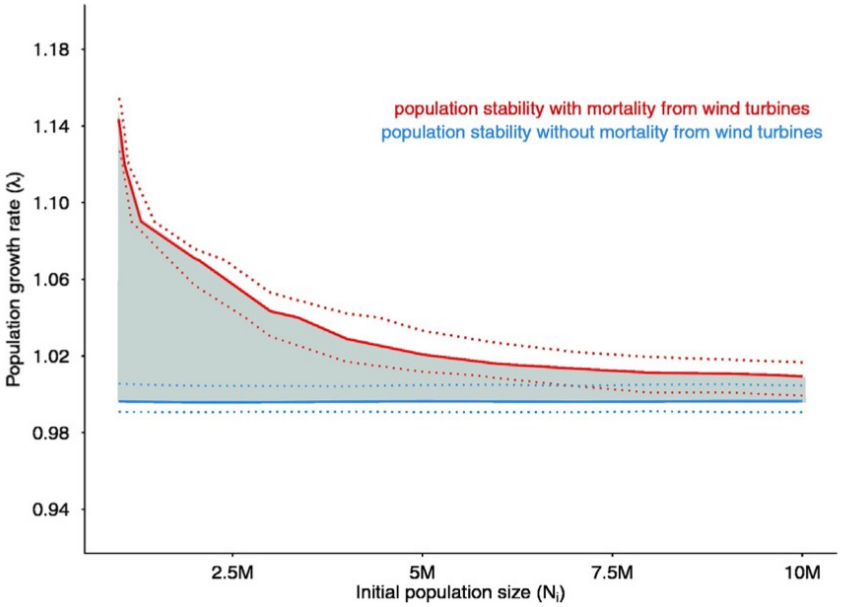


Photo: Bruce D. Taubert

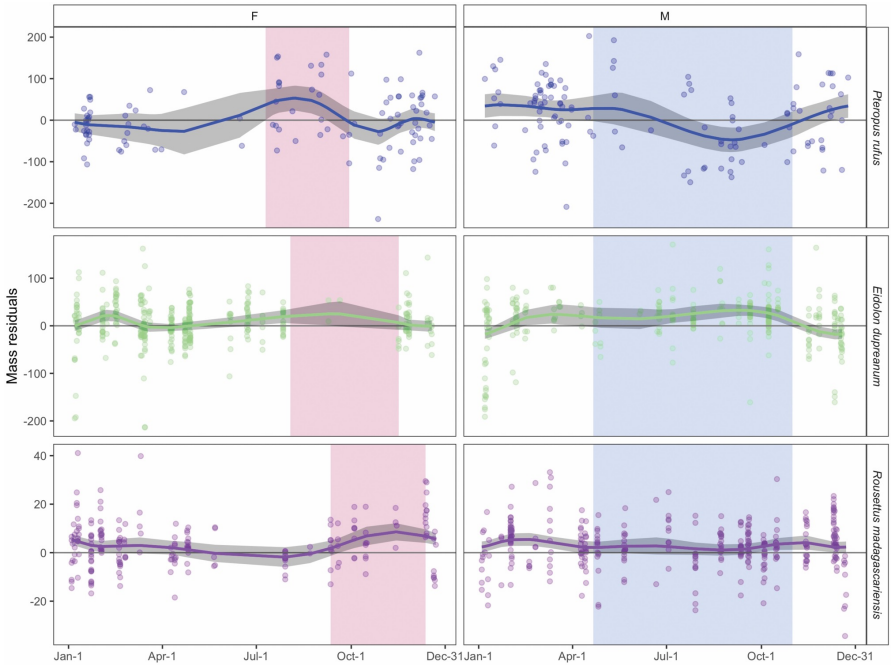
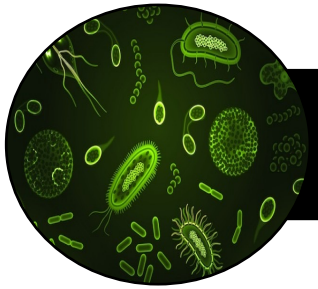


Photo: Michael Durham

Peixoto, 2018

Andrianiaina, 2022

Frick, 2012



Science of disease ecology

Disease ecology is a sub-discipline of ecology that draws inspiration from many disciplines

- Public health
- One health
- Community ecology
- Population ecology
- Conservation biology
- Molecular biology

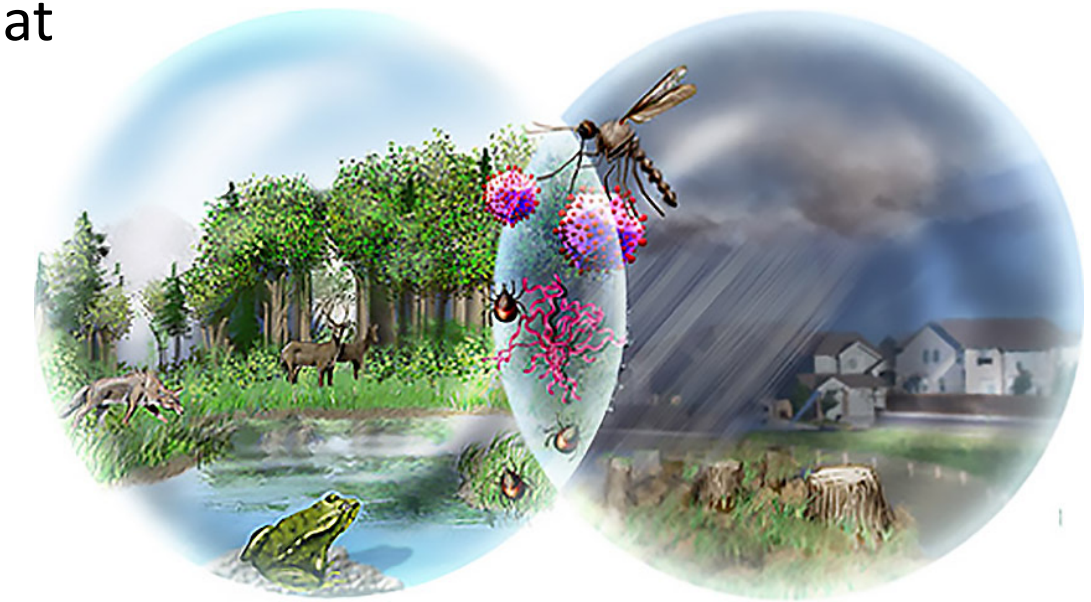
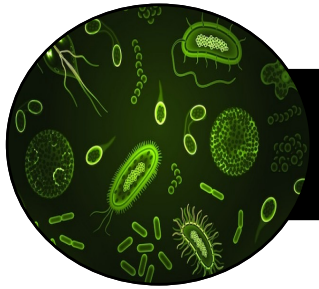


Image: Nicole Rager-Fuller

Science of disease ecology

Disease ecology: ecological study of host-pathogen interactions within the context of their environment and evolution

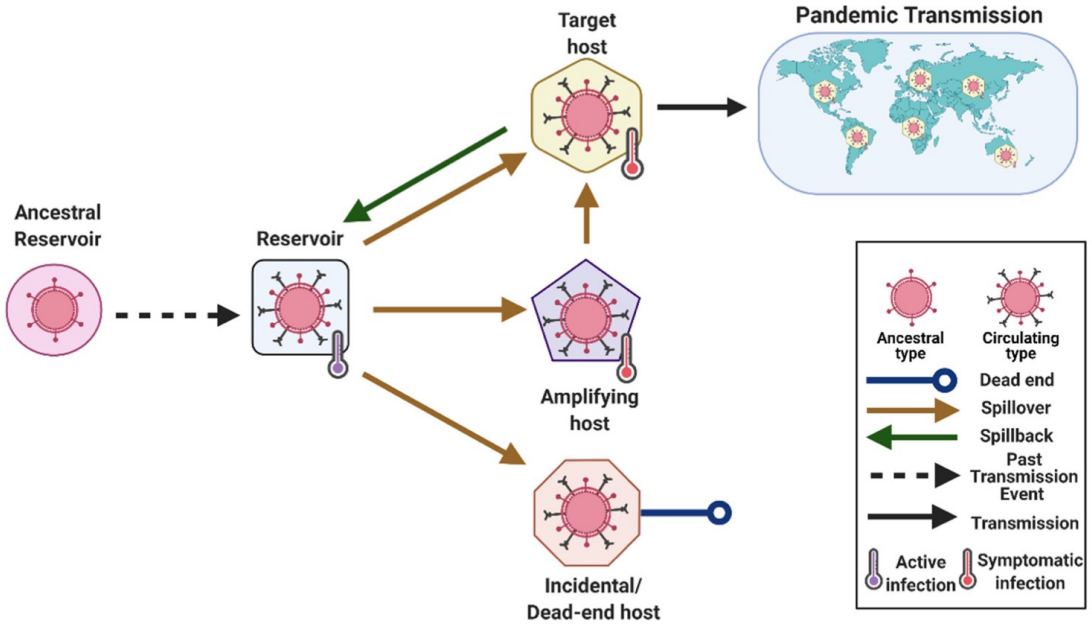
But what is a pathogen? Are we all talking about the same thing?



Science of disease ecology

Setting the Terms for Zoonotic Diseases: Effective Communication for Research, Conservation, and Public Policy

by Julie Teresa Shapiro [1,*], Luis Víquez-R [2], Stefania Leopardi [3], Amanda Vicente-Santos [4], Ian H. Mendenhall [5], Winifred F. Frick [6,7], Rebekah C. Kading [8], Rodrigo A. Medellín [9], Paul Racey [10] and Tigga Kingston [11,*]

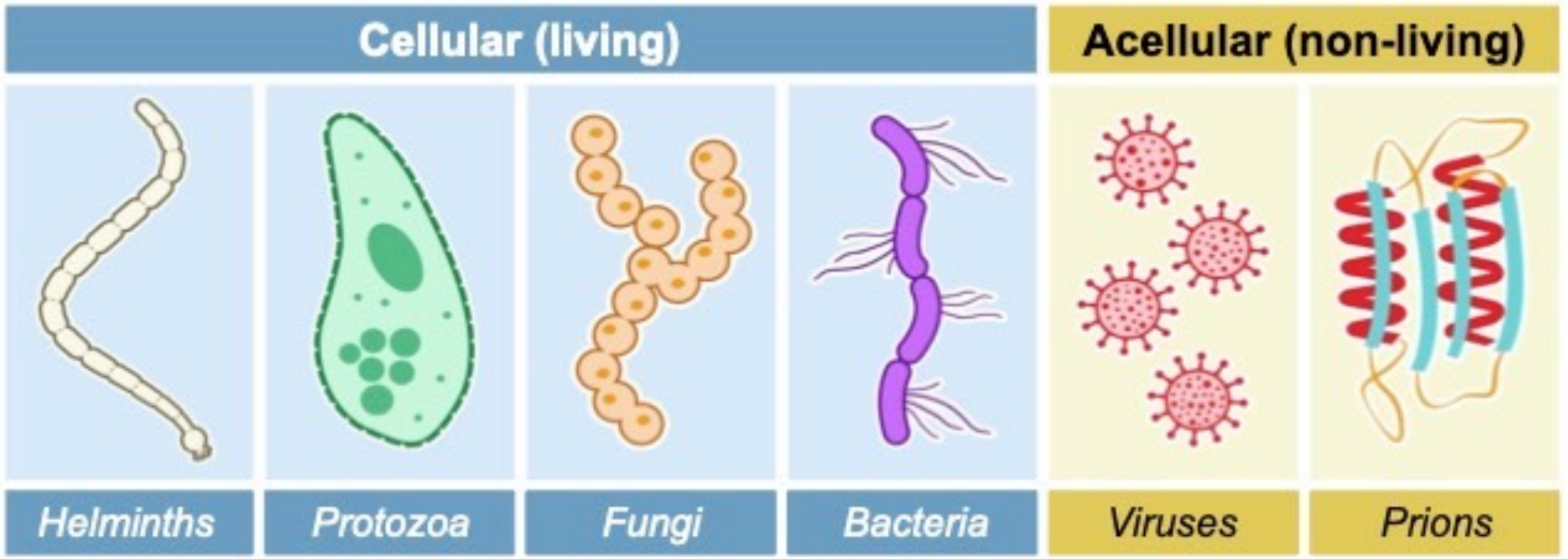


Terminology matters!

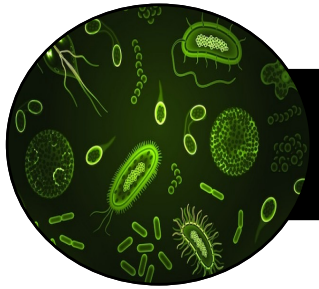
Science of disease ecology

Types of microbes/microorganisms (or parasites)

- **Microbe**: not shown to cause damage or disease in host
- **Pathogen**: shown to cause damage or disease in host



Tapeworm	Malaria	White nose syndrome	E. coli	Influenza	Mad cow disease



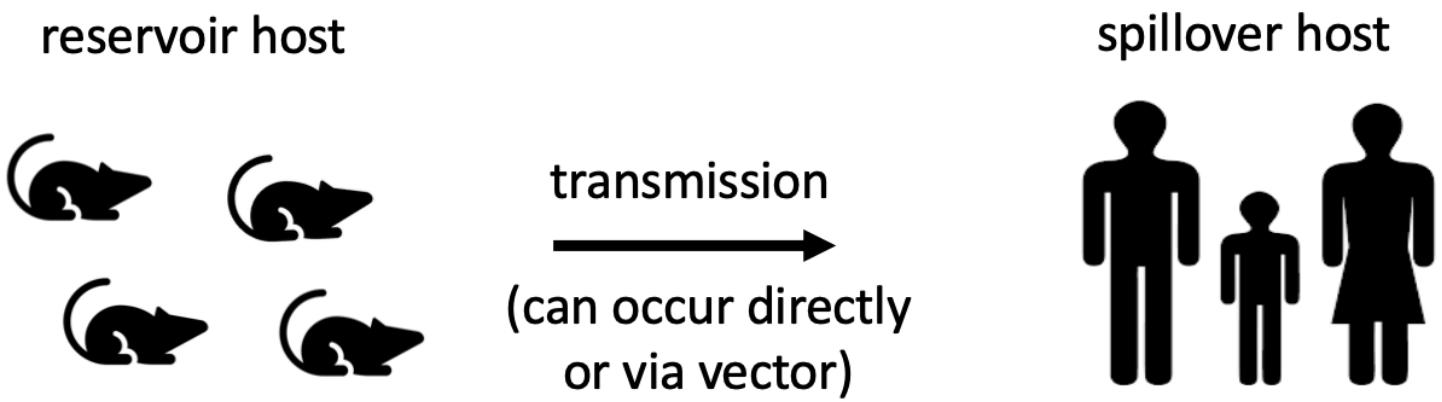
Science of disease ecology

- Disease: a pathogenic condition of a host sometimes caused by a pathogen or parasite; thus, diseases are not transmitted between hosts but pathogens and parasites that cause disease are.
- Host: an organisms that is housing the microbes and allowing a place to replicate and live
- Reservoir: a population, species or community in which a microorganism naturally occurs and is indefinitely maintained
- Vector: arthropod hosts of a microbe, like ticks
- Shedding: the expulsion of disease-causing microorganisms into the environment

Kilpatrick, 2010
Shapiro, 2021

Science of disease ecology

spillover

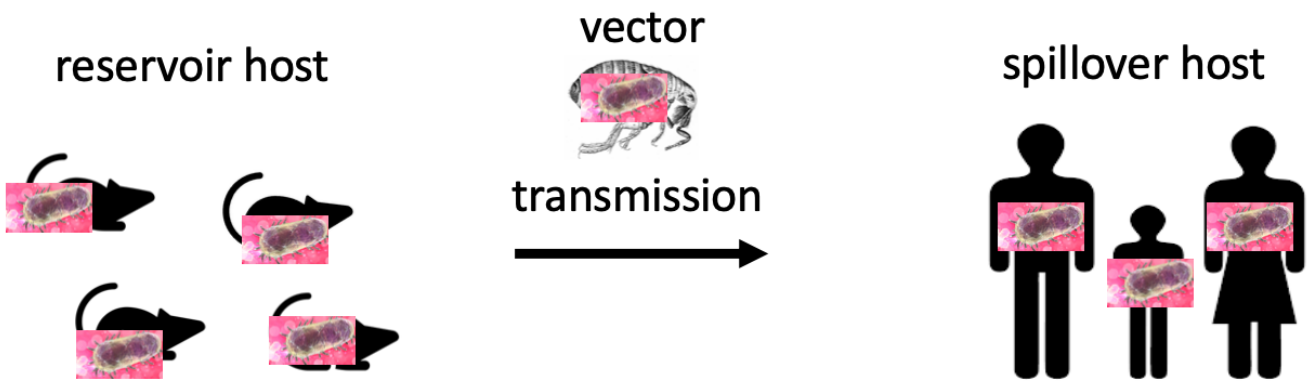


Spillover occurs when a pathogen transmits from one species to another, it could cause harm to the spillover host or it could do nothing

Brook, 2023

Science of disease ecology

zoonosis



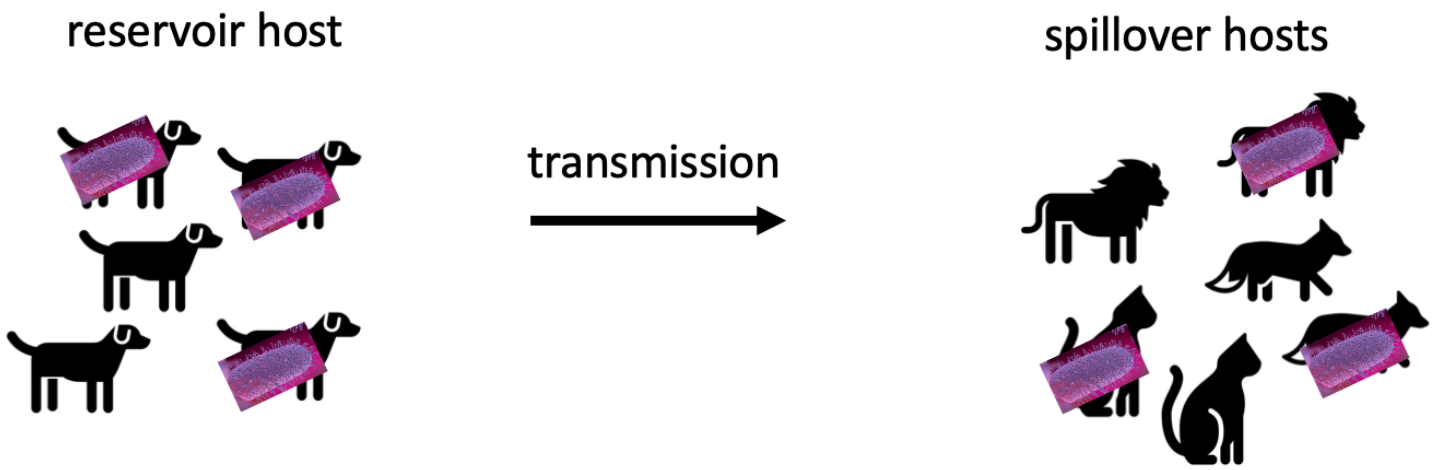
Over 60% of all 'emerging' infectious diseases are **zoonotic**, meaning transmitted from an animal reservoir to a human host.

Animal hosts are not vectors!

Brook, 2023

Science of disease ecology

Pathogens can also spillover to alternative wildlife hosts.



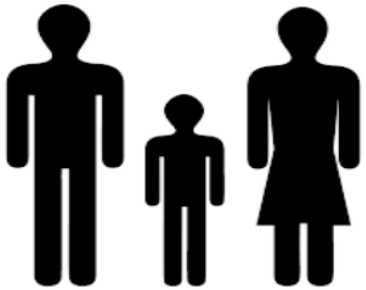
These pathogens **are not considered zoonoses** unless they spillover to humans!

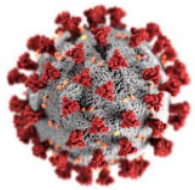
Brook, 2023

Science of disease ecology

spillback

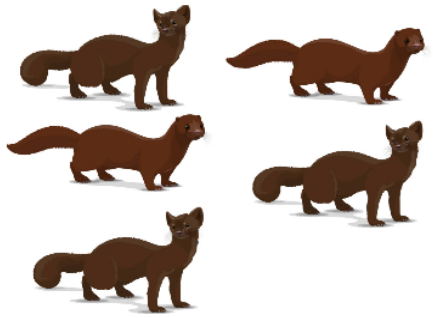
reservoir host





transmission

spillover host



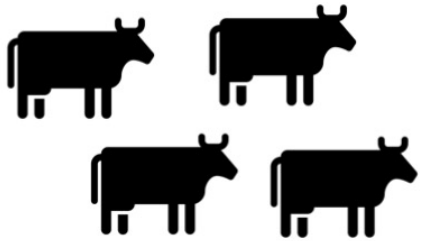
when pathogens transmit from a spillover host back to the original reservoir host

Brook, 2023

Science of disease ecology

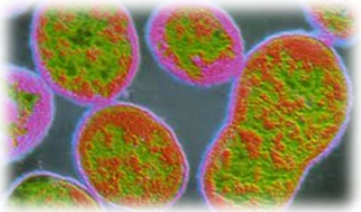
Spillback occurs among wildlife as well

reservoir host

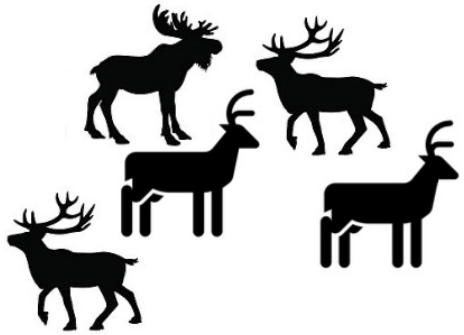


cattle

transmission



spillover hosts



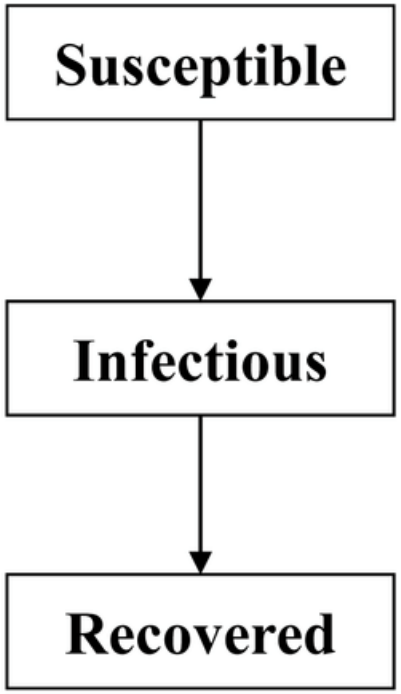
wild ungulate

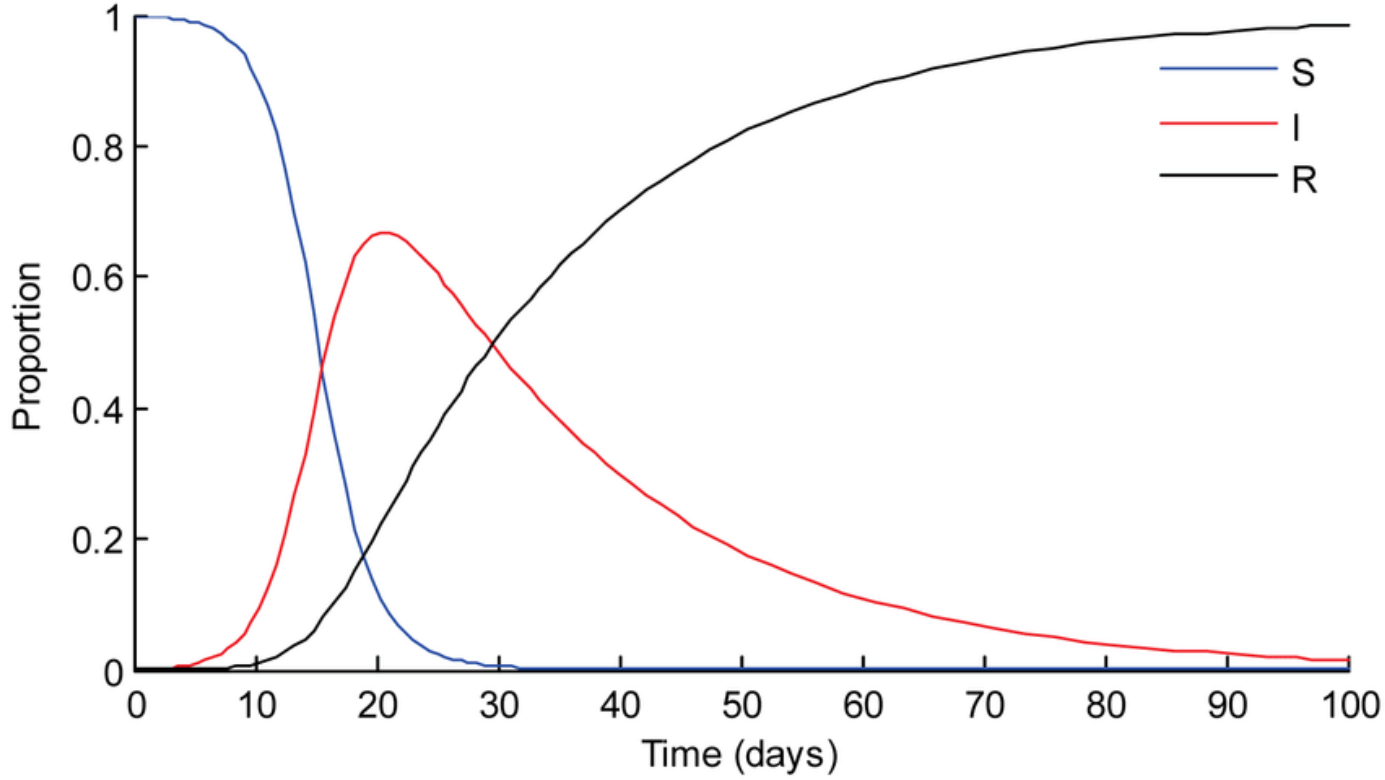
Cattle sourced *Brucella* to wild ungulates in Yellowstone National Park, which now serve as a source for reinfection to cattle.

Brook, 2023

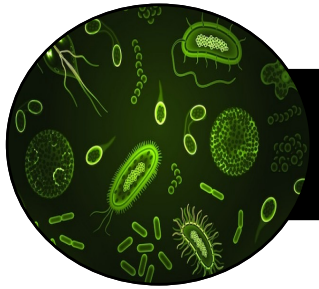
Science of disease ecology

Susceptible-Infected-Recovered models explain and predict, producing simulated data that is comparable against observed data through model fitting



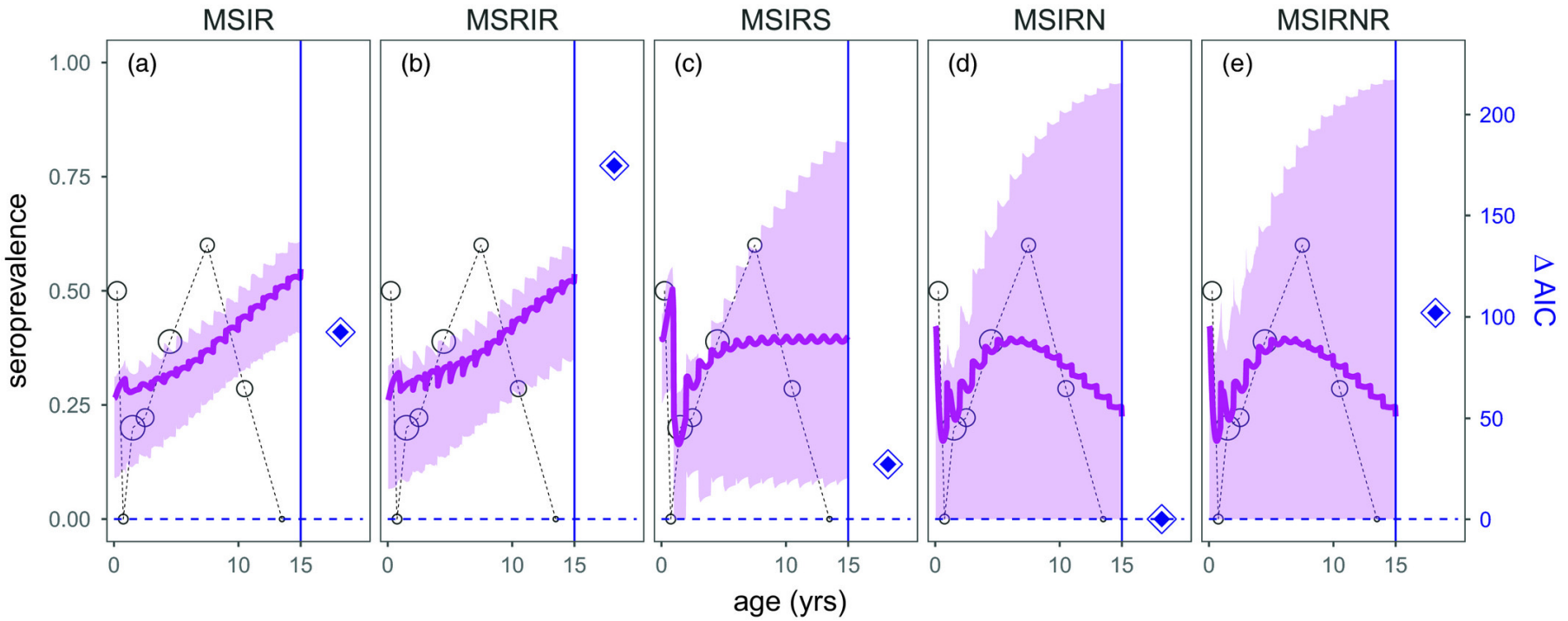


Luz, 2010

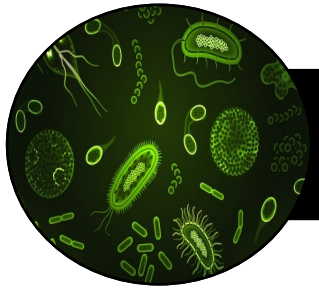


Science of disease ecology

SIR models explain and predict, producing simulated data that is comparable against observed data through model fitting



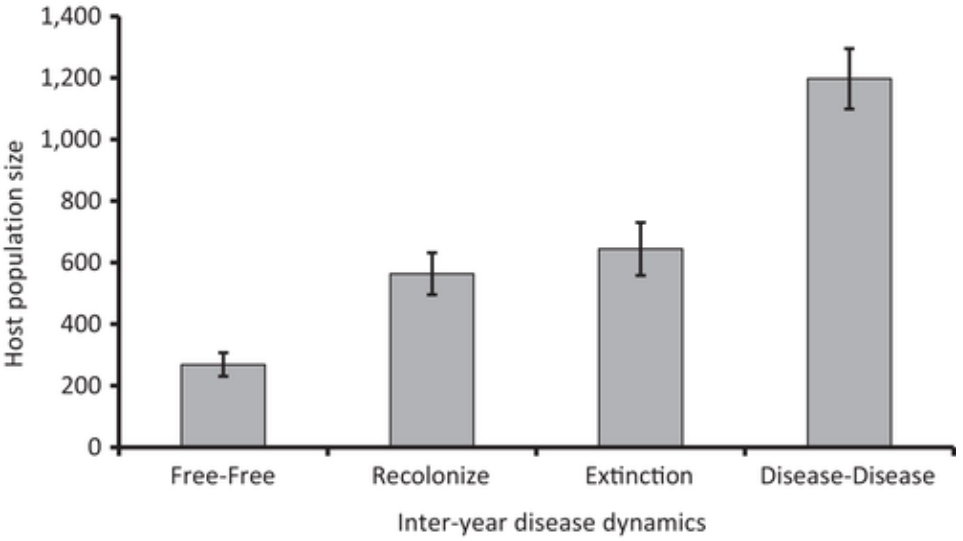
Brook, 2019



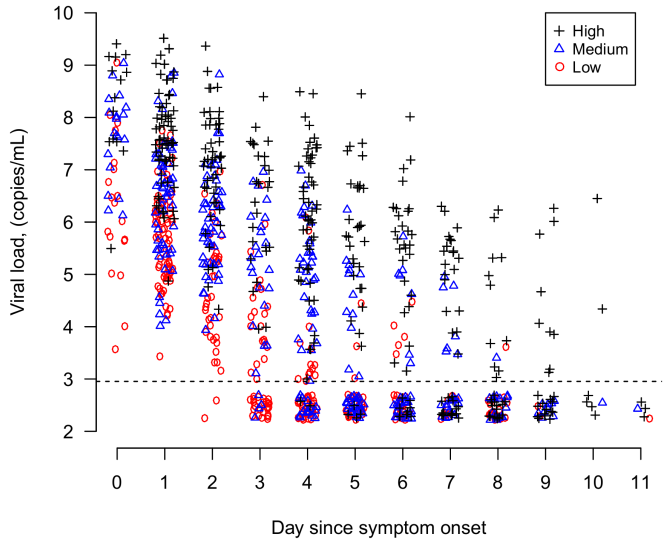
Science of disease ecology

What kind of data can we use in disease ecology?

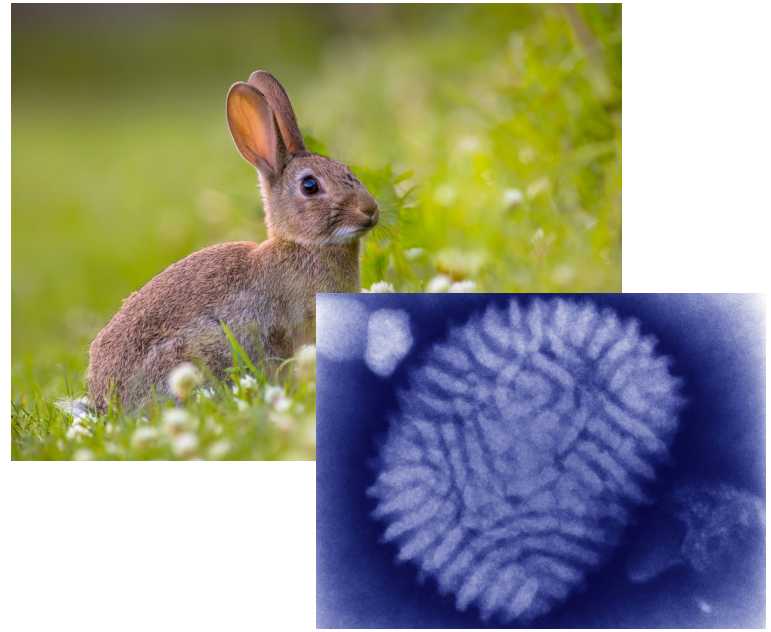
Population level



Individual level



Microbe level

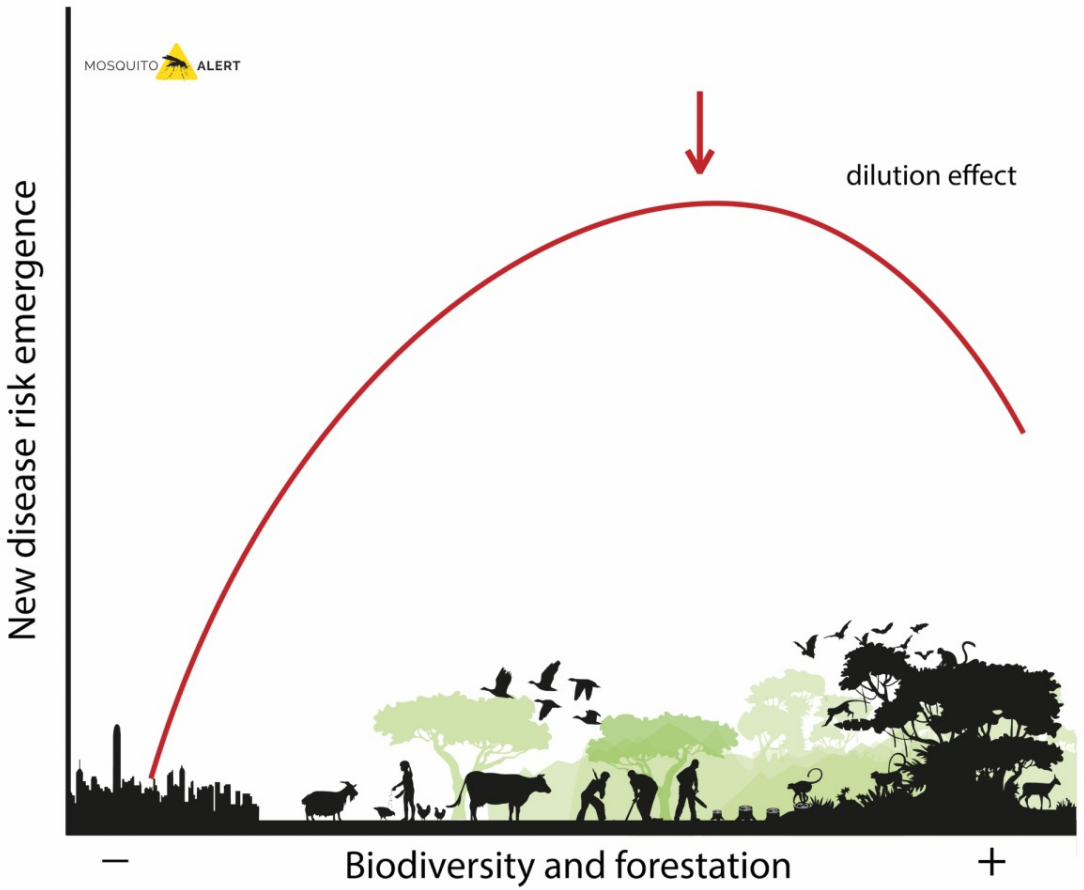


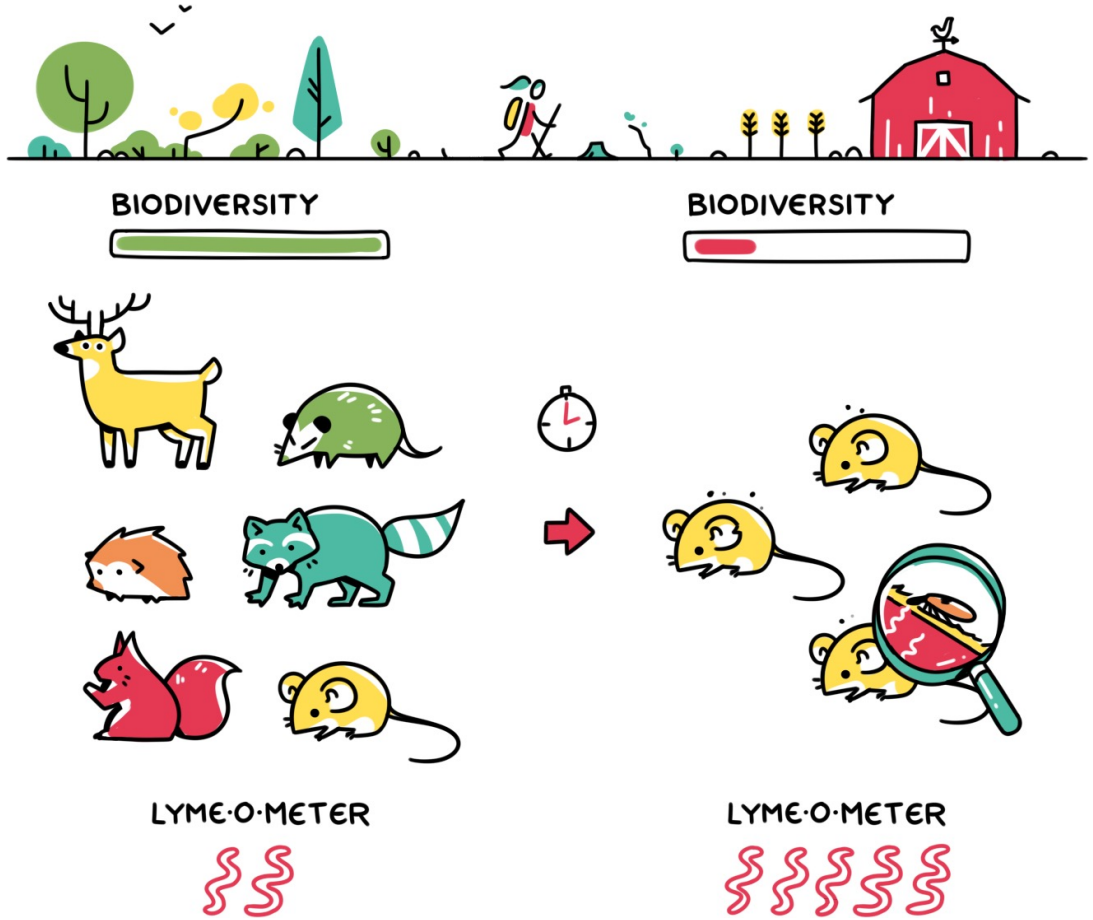
Zhan, 2021

Tsang, 2016

Science of disease ecology

We can use disease ecology to protect the health of populations

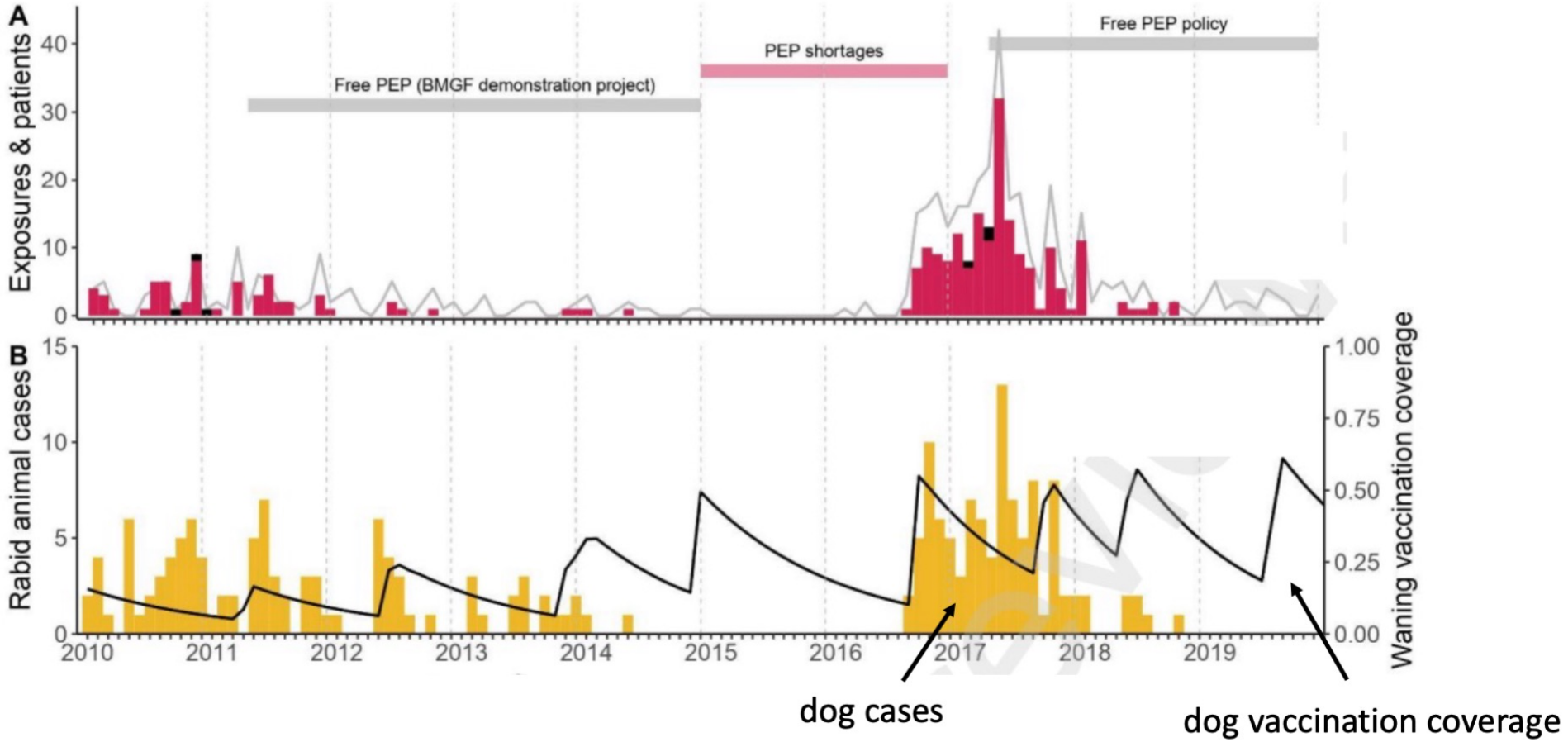




Mosquito Alert, 2020

Science of disease ecology

We can use disease ecology to make decisions to protect the health of populations



Application to bat research

Lessons from the host defences of bats, a unique viral reservoir

Aaron T. Irving, Matae Ahn, Geraldine Goh, Danielle E. Anderson & Lin-Fa Wang

Bats as Viral Reservoirs

David T.S. Hayman

Molecular Epidemiology and Public Health Laboratory, Infectious Disease Research Centre, Hopkirk Research Institute, Massey University, Palmerston North 4442, New Zealand; email: d.t.s.hayman@massey.ac.nz

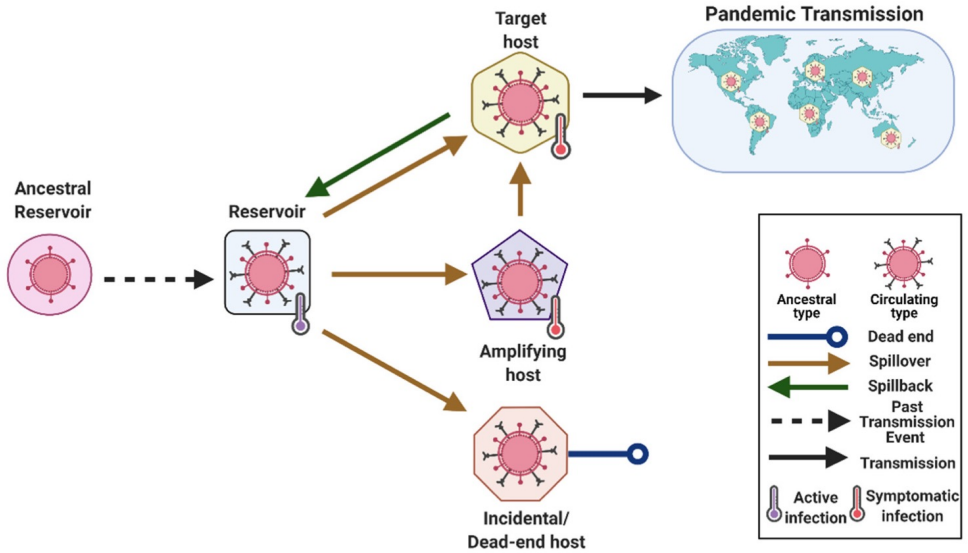
Viral zoonotic risk is homogenous among taxonomic orders of mammalian and avian reservoir hosts

Nardus Mollentze and Daniel G. Streicker Authors Info & Affiliations

Application to bat research: removing stigma

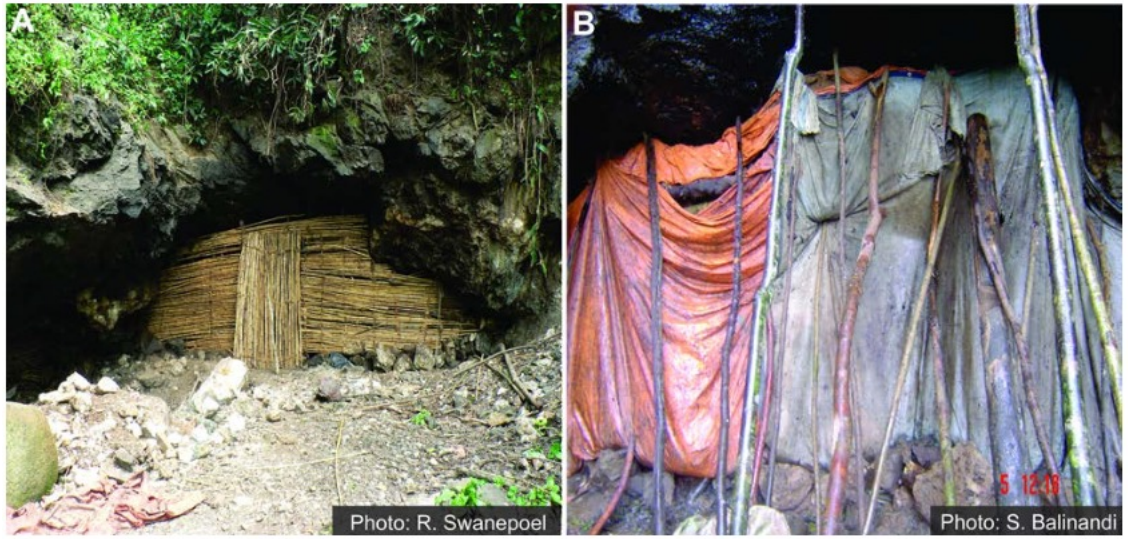
Setting the Terms for Zoonotic Diseases: Effective Communication for Research, Conservation, and Public Policy

by Julie Teresa Shapiro [1,*], Luis Víquez-R [2], Stefania Leopardi [3], Amanda Vicente-Santos [4], Ian H. Mendenhall [5], Winifred F. Frick [6,7], Rebekah C. Kading [8], Rodrigo A. Medellín [9], Paul Racey [10] and Tigga Kingston [11,*]



Marburgvirus Resurgence in Kitaka Mine Bat Population after Extermination Attempts, Uganda

Brian R. Amman, Luke Nyakarahuka, Anita K. McElroy, Kimberly A. Dodd, Tara K. Sealy, Amy J. Schuh, Trevor R. Shoemaker, Stephen Balinandi, Patrick Atimnedi, Winyi Kaboyo, Stuart T. Nichol, and Jonathan S. Towner

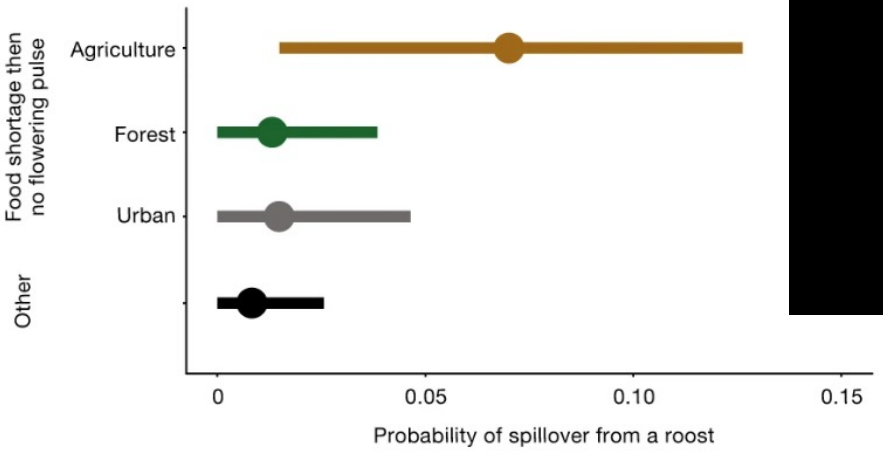


Application to bat research: habitat changes

Pathogen spillover driven by rapid changes in bat ecology

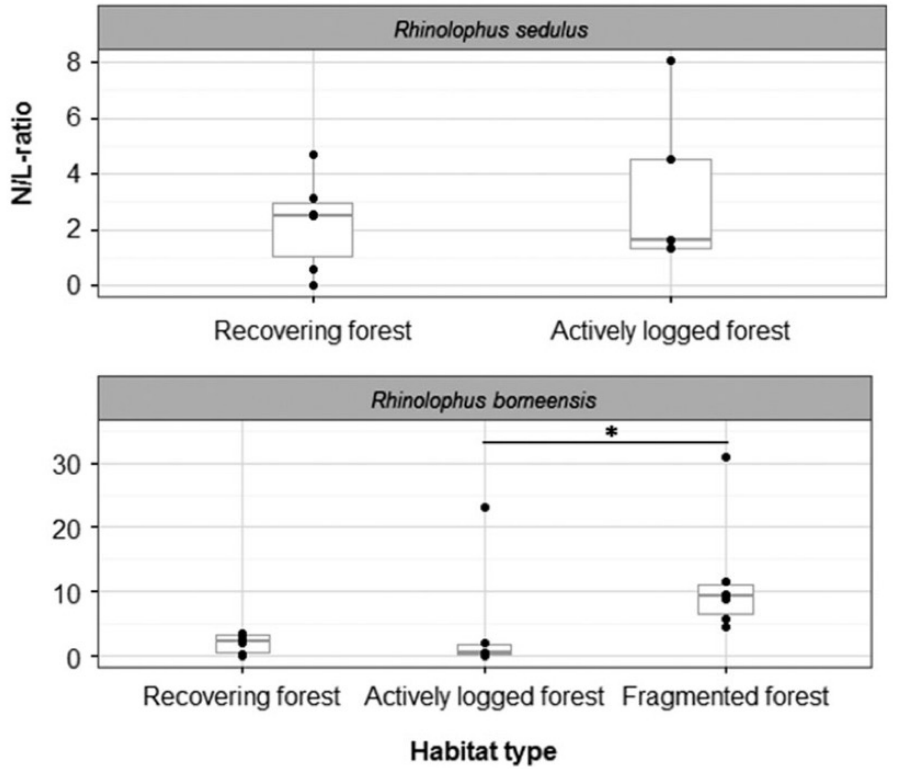
Peggy Eby, Alison J. Peel, Andrew Hoegh, Wyatt Madden, John R. Giles, Peter J. Hudson & Raina K. Plowright

Nature **613**, 340–344 (2023) | Cite this article



Habitat disturbance results in chronic stress and impaired health status in forest-dwelling paleotropical bats

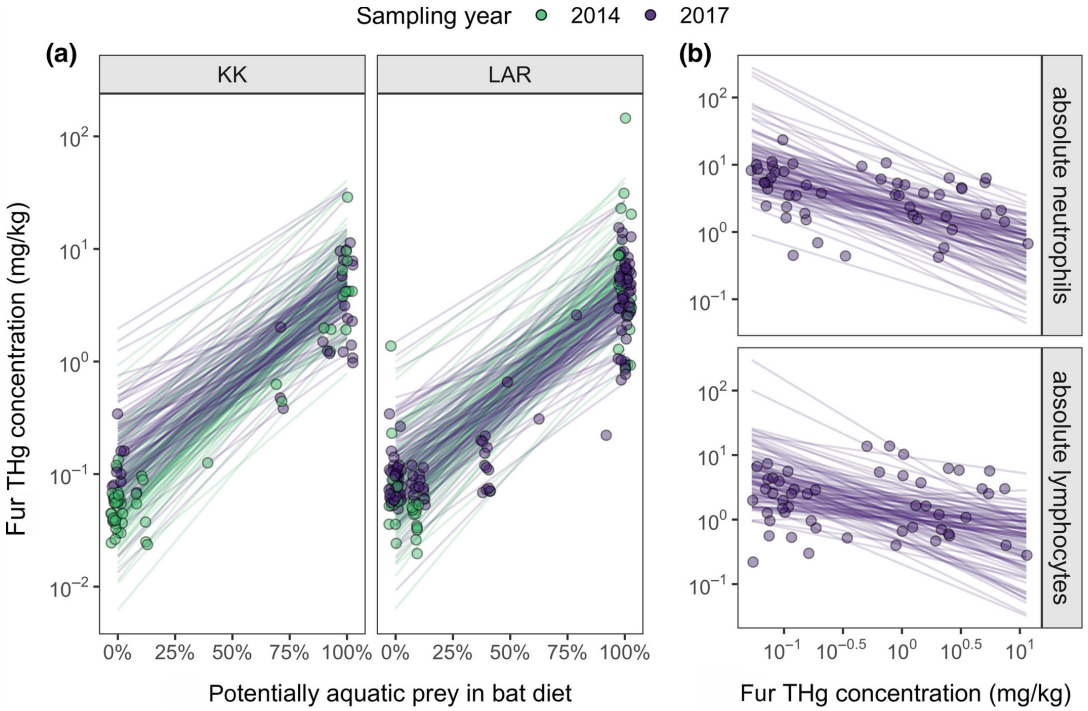
Anne Seltmann[1,2,*], Gábor Á. Czirják[3], Alexandre Courtiol[4], Henry Bernard[5], Matthew J. Struebig[6] and Christian C. Voigt[1,2]



Application to bat research: environmental impact on bat health

Disentangling interactions among mercury, immunity and infection in a Neotropical bat community

Daniel J. Becker, Kelly A. Speer, Jennifer M. Korstian, Dmitriy V. Volokhov, Hannah F. Droke, Alexis M. Brown, Catherene L. Baijnauth, Ticha Padgett-Stewart, Hugh G. Broders, Raina K. Plowright, Thomas R. Rainwater, M. Brock Fenton, Nancy B. Simmons, Matthew M. Chumchal ... See fewer authors



Article | Published: 05 August 2020

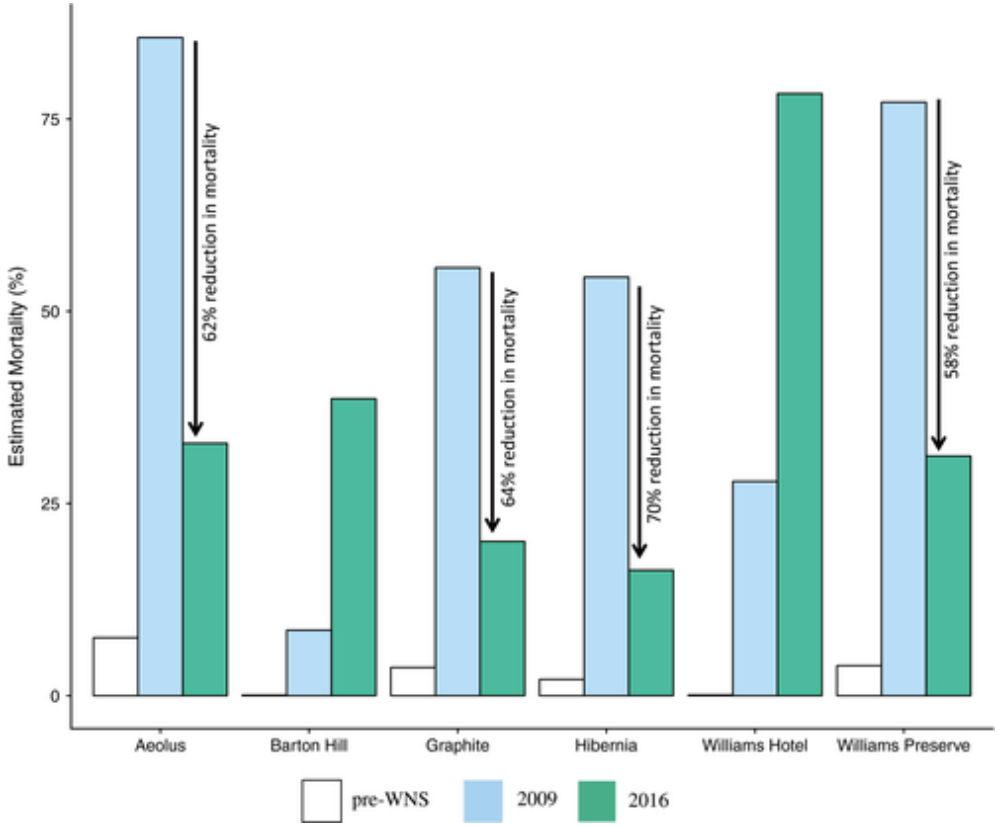
Zoonotic host diversity increases in human-dominated ecosystems

Rory Gibb, David W. Redding, Kai Qing Chin, Christl A. Donnelly, Tim M. Blackburn, Tim Newbold & Kate E. Jones

Application to bat research: some pathogens do hurt bats

Higher fat stores contribute to persistence of little brown bat populations with white-nose syndrome

Tina L. Cheng, Alexander Gerson, Marianne S. Moore, Jonathan D. Reichard, Joely DeSimone, Craig K. R. Willis, Winifred F. Frick, Auston Marm Kilpatrick



Diseases and Causes of Death in European Bats: Dynamics in Disease Susceptibility and Infection Rates

Kristin Mühldorfer, [1,*] Stephanie Speck, [2] Andreas Kurth, [3] René Lesnik, [3] Conrad Freuling, [4] Thomas Müller, [4] Stephanie Kramer-Schadt, [1] and Gudrun Wibbelt [1]

Identification of a Novel *Yersinia enterocolitica* Strain from Bats in Association with a Bat Die-Off That Occurred in Georgia (Caucasus)

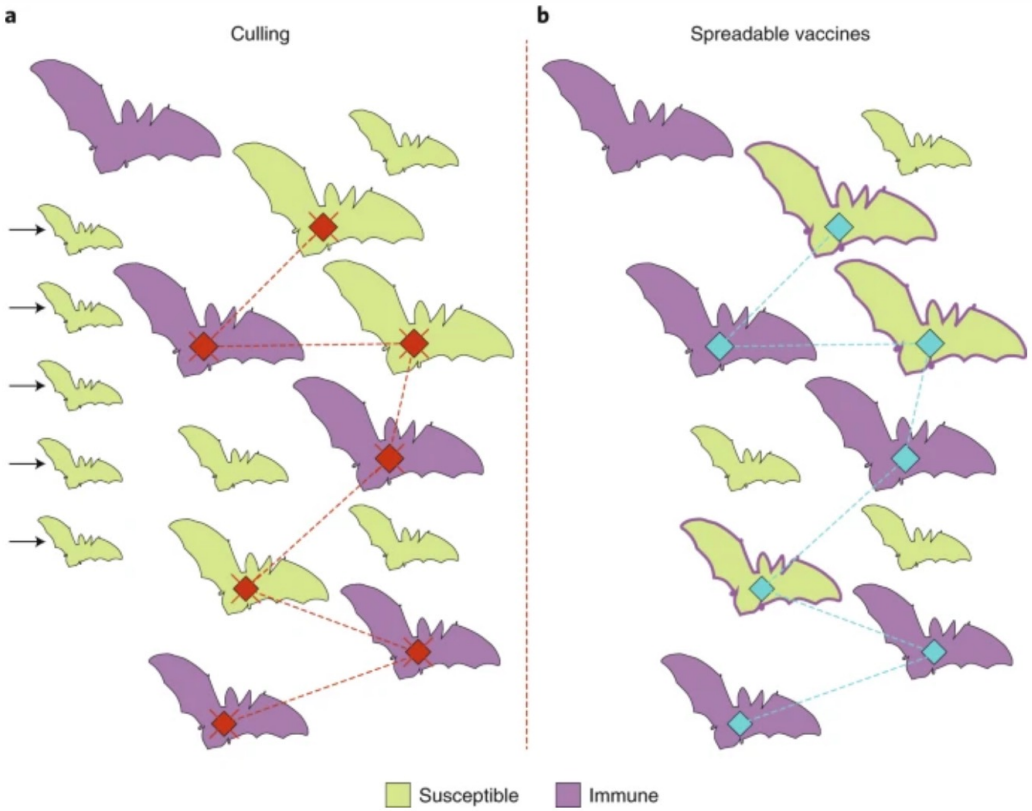
by Tata Imnadze [1,2,†], Ioseb Natradze [3,†], Ekaterine Zhgenti [1], Lile Malania [1], Natalia Abazashvili [1], Ketevan Sidamonidze [1], Ekaterine Khmaladze [1], Mariam Zakalashvili [1], Paata Imnadze [1,2], Ryan J. Arner [4], Vladimir Motin [5] and Michael Kosoy [6,*]

Rabies can cause illness in bats too!

Application to bat research: solutions to benefit bats and spillover host

Fluorescent biomarkers demonstrate prospects for spreadable vaccines to control disease transmission in wild bats

Kevin M. Bakker ✉, Tonie E. Rocke, Jorge E. Osorio, Rachel C. Abbott, Carlos Tello, Jorge E. Carrera, William Valderrama, Carlos Shiva, Nestor Falcon & Daniel G. Streicker ✉



Ecological determinants of rabies virus dynamics in vampire bats and spillover to livestock

Diana K. Meza ✉, Nardus Mollentze, Alice Broos, Carlos Tello, William Valderrama, Sergio Recuenco, Jorge E. Carrera, Carlos Shiva, Nestor Falcon, Mafalda Viana† and Daniel G. Streicker†

Application to bat research: surveillance combined with ecology

Discovery and Genomic Characterization of a Novel Henipavirus, Angavokely Virus, from Fruit Bats in Madagascar

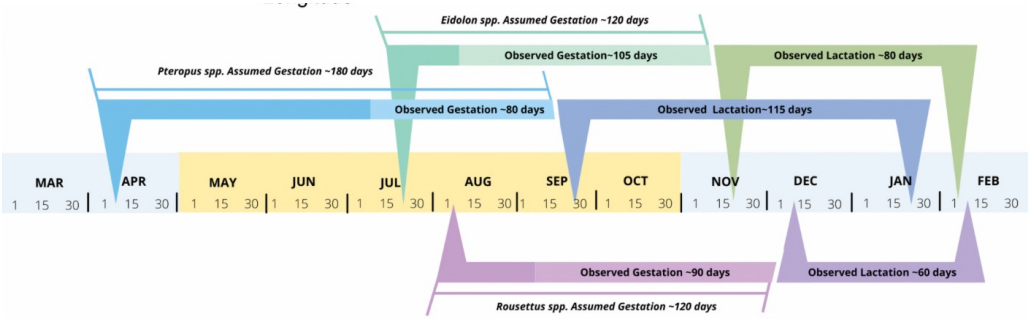
Sharline Madera [1], Amy Kistler [2], Hafaliana C Ranaivoson [3 4 5], Vida Ahyong [2], Angelo Andrianiaina [5], Santino Andry [6], Vololoniaina Raharinosy [4], Tsiry H Randriambolamanantsoa [4], Ny Anjara Fifi Ravelomanantsoa [5], Cristina M Tato [2], Joseph L DeRisi [2 7], Hector C Aguilar [8], Vincent Lacoste [4], Philippe Dussart [4], Jean-Michel Heraud [4 9], Cara E Brook [3]

Temporal and spatial limitations in global surveillance for bat filoviruses and henipaviruses

Daniel J. Becker ✉, Daniel E. Crowley, Alex D. Washburne and Raina K. Plowright

Reproduction, seasonal morphology, and juvenile growth in three Malagasy fruit bats

Angelo Andrianiaina, Santino Andry, Anecia Gentles, Sarah Guth, Jean-Michel Héraud, Hafaliana Christian Ranaivoson, Ny Anjara Fifi Ravelomanantsoa, Timothy Treuer, Cara E Brook ✉ Author Notes



In summary

Disease ecology encompasses aspects of population and conservation ecology

More work needs to be done to reduce bias in bat disease ecology research

Limitations in the field are beginning to be addressed, longitudinal temporal and spatial data can help predict potential spillovers and determine cycling of pathogens within the bat populations

Environmental variation impacts populations and their associated pathogens, it is important to disease research to not just focus on pathogen-host interactions.

Thank you for listening!

More questions?

Contact me at gkettenburg@uchicago.edu