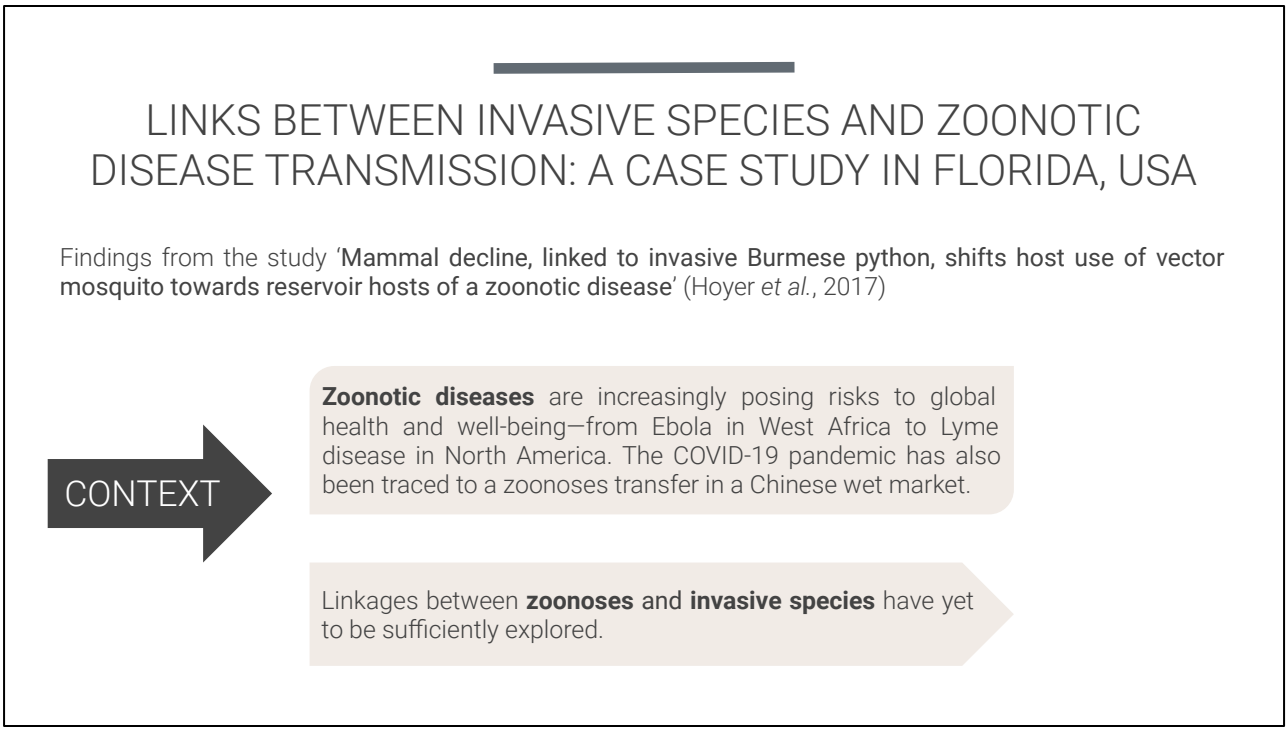


[Presentation for the scientific community]

Key talking points

- How invasive species may alter the transmission of zoonoses is an overlooked research area.
- Disease spillover is a global priority with growing urgency.
- Invasive species have the potential to create indirect trophic cascades in their non-native ecosystems (Hoyer *et al.*, 2017).
- More diverse communities can reduce zoonotic risk through dilution: decreasing vector contact with pathogen reservoirs (Hoyer *et al.*, 2017). Invasive apex predators may then increase zoonotic risk by reducing ecosystem diversity.

Unless otherwise noted, all images are open source.

CASE STUDY BACKGROUND

INVASIVE BURMESE PYTHON POPULATION

LESS MAMMALIAN DIVERSITY IN THE EVERGLADES

COTTON RAT: EVERGLADES VIRUS (EVEV) RESERVOIR HOST

***CX. CEDECEI* MOSQUITO: EVEV PRIMARY VECTOR**

RESEARCH QUESTION

What are the potential impacts of the community effects of Burmese pythons on contact between reservoir hosts and vectors of EVEV?

Key talking points:

- Research has shown that invasive Burmese pythons (*Python bivittatus*) are reducing the numbers of mammals in Everglades National Park by 80–99%, including raccoons, rabbits, deer, and opossums (Dorcas *et al.*, 2012; McCleery *et al.*, 2015; Willson, and Driscoll, 2017).
    - Everglades National Park is a biodiversity hotspot and unique for its biotic communities (McCleery *et al.*, 2015).

- Example, if needed: Forest fragmentation in North America has led to reduced mammalian diversity. With fewer predators, a competent Lyme disease host, the white-footed mouse (*Peromyscus leucopus*), has experienced increased population growth and density, leading to more contact with disease vectors (Hoyer *et al.*, 2017).

- Hoyer *et al.*'s 2016 study researched how ecological cascades, likely spurred by the Burmese pythons, may be affecting Everglades virus (EVEV) host-vector interactions (2017).
    - The Everglades virus is a mosquito-borne zoonotic Alphavirus, and it causes nonfatal neurological disease in humans (Hoyer *et al.*, 2017).
    - ***Culex cedecei* mosquitoes** are the known EVEV vector.
    - The primary EVEV reservoir is the **hispid cotton rat** (*Sigmodon hispidus*).

METHODOLOGY

1. Everglades sampling conducted at **eight locations** in the same habitat used in the analogous 1979 study
2. Sampling conducted on **20 days across five non-consecutive months**
3. Blood-fed *Cx. cedecei* sampled inside and outside python range using **resting shelters** with **14–27 samples per day**
4. **PCR-based blood meal analysis**
5. Chi-squared test to compare **bloodmeal data** with 1979 study (prior to python proliferation)
6. Poisson regression modelling to compare ***Cx. cedecei* abundance** inside and outside python range

An entomologist researching mosquitoes in the Everglades (Reeves, 2018)

Key talking points:

- An analogous 1979 survey (prior to python introduction) guided the selection of sampling locations to collect and analyze *Cx. cedecei* bloodmeals (Hoyer *et al.*, 2017).
- Sampled *Cx. cedecei* in Vero Beach, Florida, outside the python range.
- Used chi-squared tests to compare historical and current distribution of:
    - Total bloodmeals
    - Reservoir versus non-reservoir bloodmeals in the Everglades
    - Seasonal patterns of reservoir versus non-reservoir bloodmeals

FINDINGS

1

Pet owners release pythons, and the species becomes established.

2

Through predation and competition, pythons decimate local mammal populations.

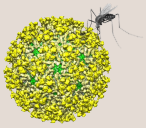
3

With fewer predators and fast reproduction, the hispid cotton rat thrives. It is also a competent host of EVEV.

4

From 1979 to 2016, mosquito feedings on cotton rats increase more than 400%.

5



Cx. cedecei mosquitoes are the enzootic vector of EVEV.

6

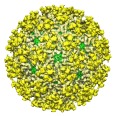
The changes in ecosystem dynamics will likely result in increased virus transmission to humans.

Key talking points:

- Compared to 1979 data, mosquito feedings on hispid cotton rats increased from 14.7% to 76.4% of total bloodmeals (increase of 419.7%) (Hoyer *et al.*, 2017).
- In contrast, mosquito feedings on deer, raccoon and opossum in the Everglades decreased from 45.1% to 0.8% of total bloodmeals (Hoyer *et al.*, 2017).
- In Vero Beach, *Cx. cedecei* mosquitoes fed on a wider diversity of animals, and hispid cotton rats only accounted for 18.1% of bloodmeals (Hoyer *et al.*, 2017).
- The Everglades have experienced substantial shifts in host-use that correspond to the invasion and proliferation of pythons and the declines in mammalian diversity (Hoyer *et al.*, 2017).
- Increased vector feedings on a highly competent host should increase disease transmission to humans (Hoyer *et al.*, 2017).

RECOMMENDATIONS FOR FUTURE RESEARCH

Quantify pathogen prevalence to determine if the cascading ecological impacts lead to changes in human disease risk



Expand logic model to study other locations with established invasive apex predators

Key talking points:

- Hoyer *et al.*'s study is the first indication of an invasive apex predator indirectly increasing contact between a disease vector and reservoir hosts (2017).
- Due to a lack of historical data, the researchers could not compare percentages of infected vectors, which is a better predictor of the risk of disease (Hoyer *et al.*, 2017).
- Future studies can measure the prevalence of EVEV to better understand linkages to disease risk (Hoyer *et al.*, 2017).
- The novel study also presents a model that can and should be applied to similar species invasions.

THE GLOBAL CONTEXT

Key talking points:

- In 2020, the World Economic Forum's annual global risk assessment placed "biodiversity loss" as one of the top five risks to the world (2020). Likewise, the report notes that infectious diseases (such as Ebola, SARS, Zika, and MERS) can present grave challenges to global health and economic security (2020).

- We are, unfortunately, now seeing this warning fulfilled as the COVID-19 pandemic stretches humanity and healthcare systems to new limits.

- **COVID-19 has created a new urgency in examining human and animal interactions. The more we understand, the more we all will benefit in the future.**

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