

### Role of Wood Frogs & Community Composition in Ranavirus Outbreaks

Lloyd-Smith et al. (2009)

UT CVM<sup>1</sup>

Matthew J. Gray<sup>2</sup>, Patrick N. Reilly<sup>1,2</sup>, Roberto Brenes<sup>2</sup>, Jordan C. Chaney<sup>2</sup>, Rebecca P. Wilkes<sup>1</sup>, Rachel D. Hill<sup>2</sup>, and Debra L. Miller<sup>1,2</sup>

Global Ranavirus Consortium Course  
23 March 2016

UT CWH<sup>2</sup>

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### Wood Frog

Wood Frog, *Rana sylvatica*

Hoverman et al. (2011)

Survival (%)

Day of experiment

Wood frog

Of the 38 amphibian species tested, among the top 3 most susceptible species.

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### Widespread Cases: Wood Frog

Seven Canadian Provinces

12 U.S. States

Duffus et al. (2015)  
D'Aoust-Messier et al. (2015)  
S. Smith (unpubl. data)  
B. Rothermel (unpubl. data)  
M. Gahl (unpubl. data)

More Ranavirus Die-offs in the Wild than any other Species

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### Classical Cases: Wood Frogs

Wheelwright et al. (2014): ME




>200,000 Tadpoles  
in 24 hours

Green et al. (2002), Todd-Thompson (2010): TN



Community-level  
Effects?



**B**  
Survival (%)  
100  
80  
60  
40  
20  
0  
Marbled salamander

Hoverman et al. (2011)

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
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### Grim Reaper: Amplifying Species





Ranavirus



Persistence

Dispersal

Host Community

Contact Rate

**Disease Hotspots**

95-100%

Superspreading Individuals

Shedding Rate

Contact

Lloyd-Smith et al. (2005)

Amplification Species

Susceptibility

Contact Rate

**REVIEWS** REVIEWS REVIEWS

**From superspreaders to disease hotspots: linking transmission across hosts and space**

Shen H, Duell R, Ngia Song, Katherine M McClain<sup>1</sup>, Loren C Seckler<sup>1</sup>, A Maria Kippenick<sup>1</sup>, and Peter T J Johnson<sup>1</sup>

2012

**Frontiers in Ecology and the Environment**

10:75-82

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### OBJECTIVES

- ▶ Test whether **superspreading** occurs for two common amphibian host species (wood frog and Cope's gray treefrog)
- ▶ Test for differences in **viral shedding** and **contact rate** between host species: which contributes more to initiate outbreaks?
- ▶ Test whether infected wood frog tadpoles co-housed with uninfected Cope's gray treefrog tadpoles results in **amplified infection & mortality**

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**Methods:**

**Highly Susceptible Species**

- Wood frog (*Lithobates sylvaticus*)  
95-100% Mortality


**Moderately Susceptible Species**

- Cope's gray treefrog (*Hyla chrysoscelis*)  
35-70% Mortality


**FV3-like Ranavirus**

- American bullfrog (GA)

**Standardized: Gosner 30**



Wood frog tadpole



Cope's gray treefrog tadpole

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**EXPERIMENTAL DESIGN**

**Inoculation**



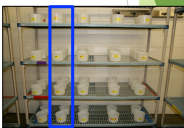
- 20 individuals
- 1 liter of water
- 3 day exposure
- 10<sup>7</sup> PFU/ml

**6-Hour Co-habitation**

- One exposed individual introduced to tub
- 5

**Individual Monitoring**

- 20 exposed were euthanized tested for infection using qPCR
- Others separated into 2-L tubs with 1-L of water.
- Monitored for 14 days

Individuals from the same tub, PCB design

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**Results: Wood frog**

**Percent Mortality:**

Day 5

Day 10

Day 14

**% Infection**

Transmission in All Tubs

17/20 = 85% Superspreading Occurred

**20-80 Rule:**  
≤20% of Individuals Result in ≥80% of Transmission

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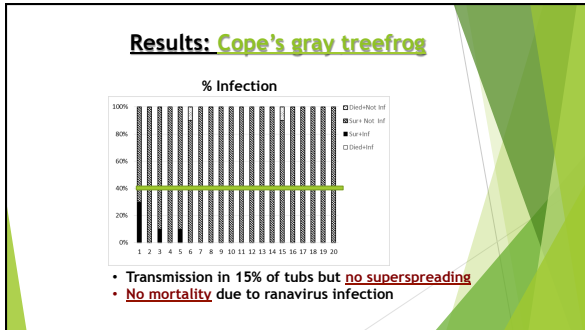
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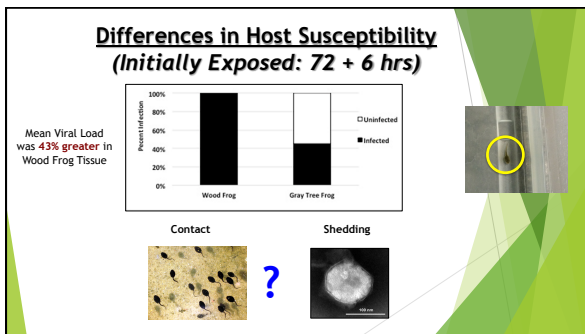
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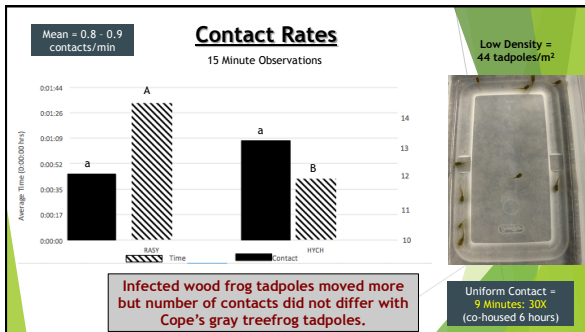
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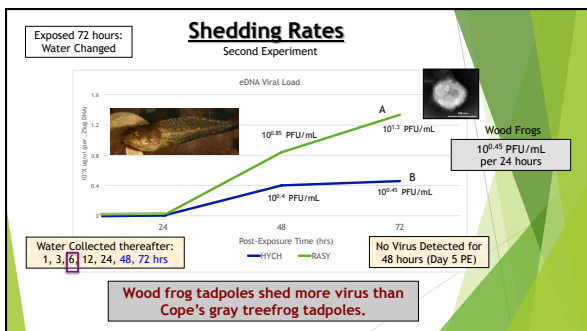
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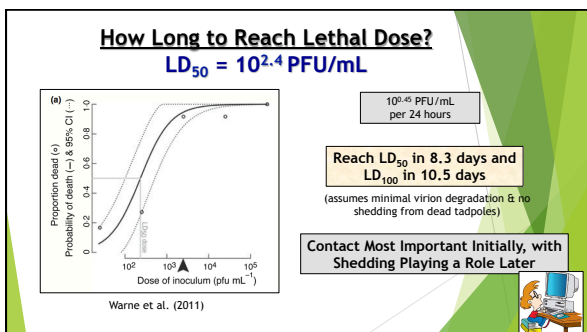
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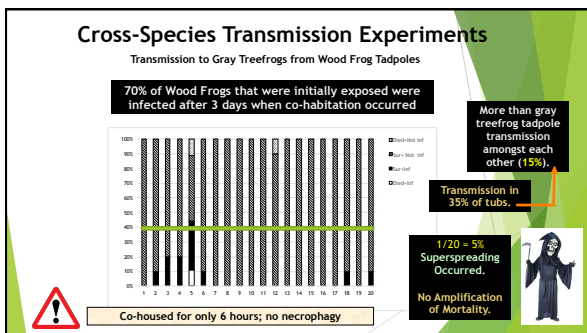
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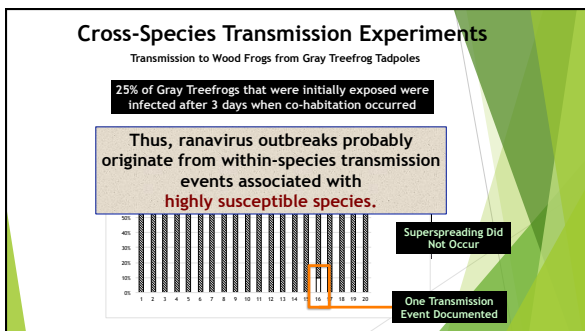
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### SUMMARY

- ▶ Probability of ranavirus transmission differs among species.
- ▶ Wood frog tadpoles are **superspreaders** of ranavirus but amplification may depend on other host species (highly susceptible) present.
  - ▶ **Limitations:** Co-housed for 6 hours, Necrophagy not included.
- ▶ **Contact** of individuals probably initiates an outbreak, but **shedding** may be more important later and result in high environmental concentrations that result in rapid transmission and mortality of less susceptible species.



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### Community Level Transmission

Brenes, Gray, Hoverman & Miller (unpubl. data)

**Objective #2:**  
Mesocosm Experiment



Inoculated in Lab  
10<sup>7</sup> PFU/mL FY3  
Exposure Order

**Appalachian:** Wood frog, chorus frog, spotted salamander  
**Coastal Plains:** Gopher frog, chorus, southern toad

**Does Exposure Order or Composition Matter?**

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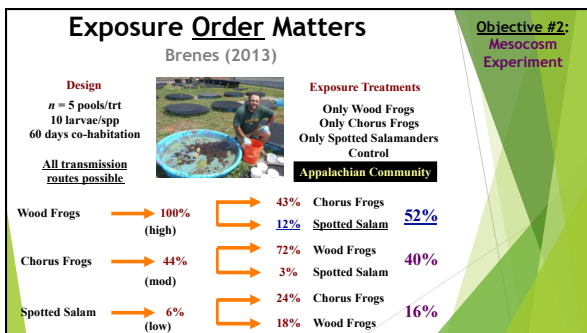
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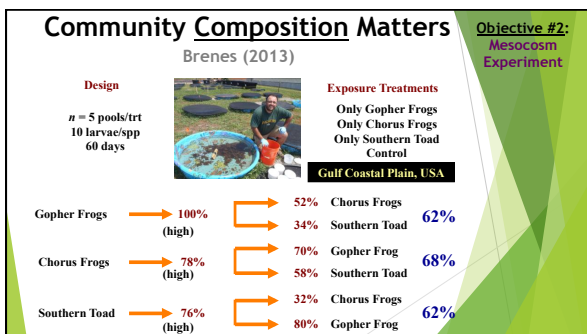
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### SUMMARY

- ▶ Our results suggest that the probability of ranavirus transmission differs among species.
- ▶ Species exposure order affects ranavirus outbreak outcomes, perhaps due to differences in virus shedding.
- ▶ Probability of an outbreak increases with the number of highly susceptible species in a community.

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### What Causes an Outbreak?



$$\frac{dS}{dt} = -\beta SI - \rho Sf(V) - \alpha SD$$

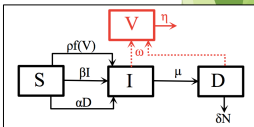
$$\frac{dI}{dt} = \beta SI + \rho Sf(V) + \alpha SD - \mu I$$

$$\frac{dV}{dt} = \omega(I + D) - \eta V$$

$$\frac{dD}{dt} = \mu I - \delta(S + I)D$$





- Contact Rates
- Shedding
- Necrophagy
- Environmental Persistence
- Density (100/m<sup>2</sup>)
- Community Composition

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### Reservoirs or Amplification Hosts?

FV3-like Ranaviruses

Gray et al. (2009)

**Reptiles**

Low Mortality (Subclinical)

Reservoir

Suitable Hosts  
Infected, Susceptible, Recovered

**Bony Fish**

Low Mortality (Subclinical)

Reservoir

Brunner et al. (2015)

**Amphibians**

Low - High Mortality (Subclinical & Clinical)

Reservoir or Amplification

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### Questions??



mgray11@utk.edu  
preilly2@utk.edu  
rbrenes@carrollu.edu  
dmille42@utk.edu





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