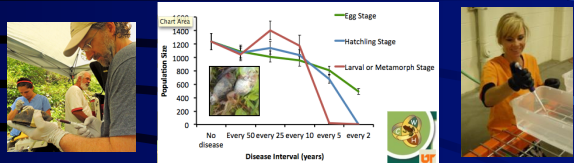


## The Emergence of Ranavirus: Why the Common Frog, Common Toad, and "Common" Wood Frog aren't so common anymore!



Matthew J. Gray<sup>1</sup> and Debra L. Miller<sup>1,2</sup>



University of Tennessee  
<sup>1</sup>Center for Wildlife Health  
<sup>2</sup>College of Veterinary Medicine




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## Outline

- I. History of Ranaviruses
- II. Effects on Host Species
- III. Can Ranaviruses Contribute to Declines?

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## Ranavirus Characteristics



- dsDNA, 150-280K bp
- 120-300 nm in diameter (3x smaller than bacteria)
- Icosahedral Shape (20)



Family: **Iridoviridae**

Genera: *Iridovirus*, *Chloriridovirus*, ***Ranavirus***, *Megalocytivirus*, and *Lymphocystivirus*

Invertebrates

Ectothermic Vertebrates

Species (6)

*Ambystoma tigrinum* virus (ATV)

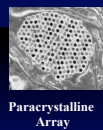
Bohle iridovirus (BIV)

Frog virus 3 (FV3)

Epizootic haematopoietic necrosis virus

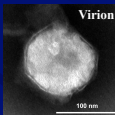
European catfish virus

Santee-Cooper Ranavirus



Paracrystalline Array

ICTV (2012)



Virion  
100 nm  
Chinchar et al. (2011)

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## Maine 2013 Die-off

**The Boston Globe**

**1000 carcasses/m<sup>2</sup>  
≥200,000 dead  
qPCR Confirmed**




Wheelwright et al.  
(2014)



<24 hrs



6/14/13 6/15/13

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## Global Distribution of Ranavirus Cases: Reptiles



Duffus et al. (2015)      4 Continents: 1982, 1990s

**Most FV3-like Ranaviruses: Captivity**

**12 Families:** Agamidae, Anguillidae, Boidae, Dactyloidae, Emydidae, Gekkonidae, Iguanidae, Lacertidae, Pythonidae, Testudinidae, Trionychidae, Varanidae  
**>30 Species**

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## Ranaviral Disease in Eastern Box Turtles

**13 February 2012**

**The Washington Post**    Make us your start page  
**POSTLOCAL**

**North Branch Stream Valley State Park**

**Deadly virus hits turtles, tadpoles in Montgomery County**



**26 of 31 Box Turtles Die from Ranaviral Disease**

**Larval anurans and salamanders dead too**

**2008 – 2011**

**Farnsworth and Seigel, Towson U.**

View Photo Gallery — Biologists say an alarming number of turtles rescued from the path of the Intercounty Connector's construction have died of a virus they fear could devastate Maryland's ecosystem.

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## Global Distribution of Ranavirus Cases: Fishes

Duffus et al. (2015)      4 Continents: 1991

**Most non-FV3-like Ranaviruses**

**22 Families:** Acipenseridae, Anguillidae, Centrarchidae, Channidae, Cobitidae, Cyprinidae, Eleotridae, Esocidae, Gadidae, Gasterosteidae, Ictaluridae, Labridae, Latidae, Lutjanidae, Moronidae, Percidae, Poeciliidae, Salmonidae, Sciaenidae, Scophthalmidae, Serranidae, Siluridae

**>50 Species**

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## How Does Ranavirus Infect A Host?

### Rapid Transmission

**Indirect Transmission**

Water or Sediment

Skin, Gills, Intestines (epithelial cells)

(3 hrs viral transcription)

**Direct Contact**

One Second Skin Contact

**Ingestion**

Necrophagy, Cannibalism, Predation

Brunner et al. (2004), Harp & Petranka (2006), Brunner et al. (2007), Hoverman et al. (2010), Robert et al. (2011)

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## Ranavirus Replication & Cell Death

Chinchar (2002), Chinchar et al. (2006), Robert et al. (2011), Hoverman et al. (2011)

12 – 32 C

**Generalized cell receptors**

**Cell death occurs within 6 – 9 hrs PI**

**Host Death as fast as 3 days**

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## Ebola of Ectothermic Vertebrates

Hemorrhages



Pale and Swollen Liver



Friable Spleen:



“Apparent tropism for vascular endothelium”  
R. Whittington

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## Gross Signs of Ranaviral Disease

Haislip, Miller, and Gray  
(unpubl. data)

*Lithobates clamitans*



*Hyla chrysoscelis*



*Lithobates sylvaticus*




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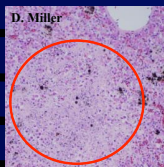
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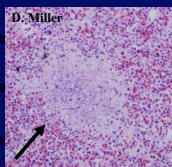
## Organ Destruction

3 Primary Organs: Liver, Spleen, and Kidney

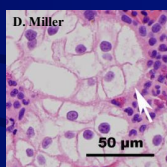
Bollinger et al. (1999)  
Miller et al. (2007, 2008)



Liver Necrosis



Spleen Necrosis



Kidney Degeneration

**Pathogenesis**  
Target Organ Failure  
Heart Failure  
Toxicosis, Anemia

Mortality Can Be Rapid!  
**Quickly as 3 days!**  
Hoverman et al. (2011a)

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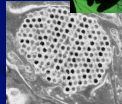
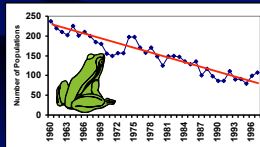
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# Are Ranaviruses Capable of Causing Local Extirpations and Species Declines?



Muths et al. (2006)



Collins & Crump (2009)




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## Evidence of Local Extinction

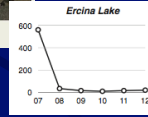
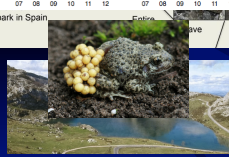
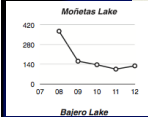
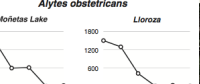


Dr. Stephen Price  
University College London  
Picos de Europa National Park

Current Biology  
24:2586-2591

2007-2012

Ranavirus die-offs  
with six species




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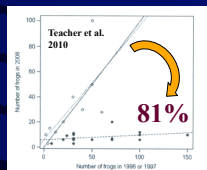
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## Evidence of Local Extinction



Dr. Amber Teacher  
Southeastern England  
1996/97 and 2008

Animal  
Conservation  
13:514-522



Ranavirus (+)  
populations  
81% Median  
Reduction



Larger Populations  
Greatest  
Proportional  
Declines

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## Evidence of Local Extinction



**Dr. Jim Petranka**  
Tulula Wetland Complex, NC  
1998-2006

Biological Conservation  
138:371-380  
Wetlands  
23:278-290

Recruitment at most wetlands failed due to **ranavirus**



Persistence Possible from **Source Populations**

Rescue Effect



**Earl et al. (2016):**  
Immigration at natural levels may be insufficient




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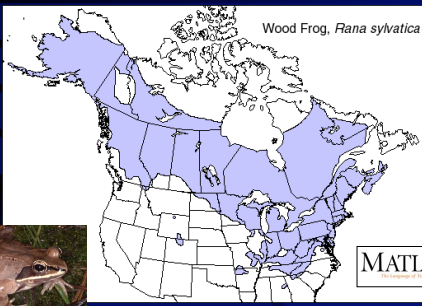
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## Any Concern for Common Species?

**Wood Frog Example**  
Most Widely Distributed Species in North America



Harper et al. (2008), Haislip et al. (2011)

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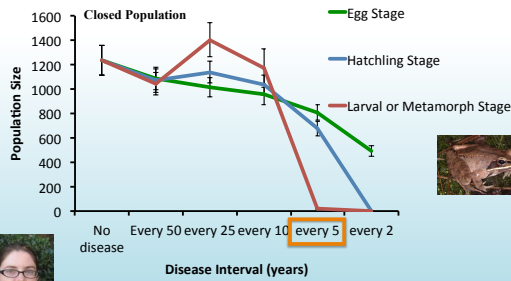
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## Female Population Size

Earl and Gray (2014)




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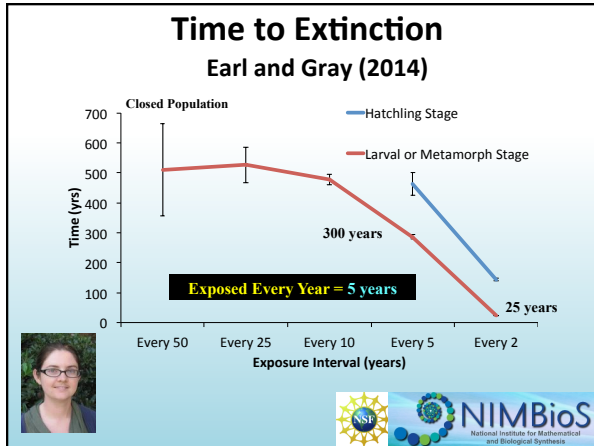
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### Cry Wolf or Valid Risk? Should we be Concerned?

- Ranavirus Die-offs have Global Distribution
- Ranavirus Prevalence can be High
- Ranaviruses Infect Multiple Ectothermic Vertebrate Species with Different Susceptibilities
- Interclass Transmission is Possible – Abundant Reservoirs
- Ranavirus Persistence can be Long (at least 1 week)
- High Transmission: Breeding and for Schooling Spp.

Epidemiological Theory, Modest Field Data, AND Initial Simulations Support the Premise that Ranaviruses Could Cause Local Population Extirpations and Contribute to Species Declines

**More Research:** What myriad of factors (abiotic, biotic; natural, anthropogenic) interact to result in ranavirus outbreaks? Few longitudinal studies & simulations.

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### Global Ranavirus Consortium, Inc.

<http://www.ranavirus.org/>

Website  
Symposia  
Reporting System  
Springer eBook

**The goal of the GRC is to facilitate communication and collaboration among scientists and veterinarians conducting research on ranaviruses and diagnosing cases of ranaviral disease**

Bylaws Approved
GRC@LISTSERV.UTK.EDU
Membership in 2015

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**UTIA**  
INSTITUTE OF  
AGRICULTURE  
at the University of Tennessee  
Real. Life. Solutions.

**Questions??**

**the FUTURE**  
of Veterinary Medicine

Photo: M. Niemiller

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<https://ag.tennessee.edu/cwh/Pages/default.aspx>



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