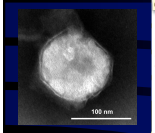
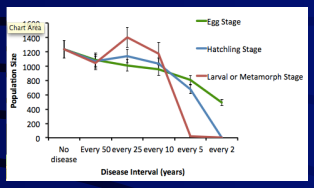
Ranaviruses:
Do they represent a real threat?

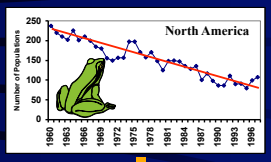




Matthew J. Gray
University of Tennessee
Center for Wildlife Health
Department of Forestry, Wildlife and Fisheries

23 March 2016, 9:00 AM, Zoom Link
Global Ranavirus Consortium Course

Presentation Road Map

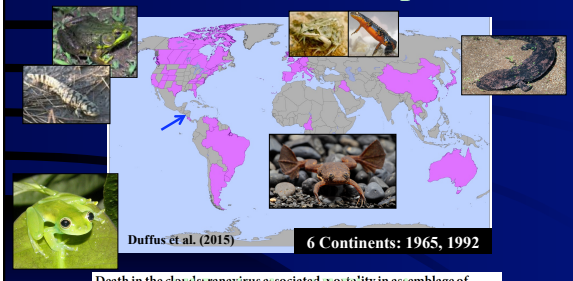


Theory

Monitoring

Simulations

Global Distribution of Ranavirus Cases: Amphibians



Death in the clouds: ranavirus associated mortality in assemblage of cloud forest amphibians in Nicaragua

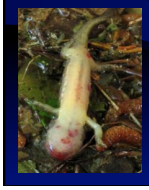
Acta Herpetologica

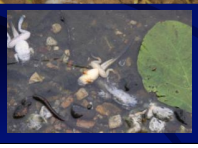
18 Families:

>100 Spec

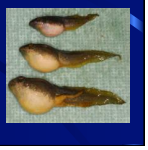
Mass Mortality Events

Larvae





Adults



Maine 2013 Die-off

The Boston Globe

1000 carcasses/m^2
≥200,000 dead
qPCR Confirmed

Wheelwright et al. (2014)

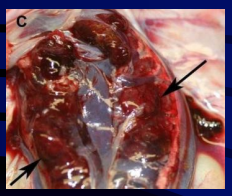
<24 hrs

6/14/13

6/15/13

Compromised Organs & Rapid Death

Kidney Hemorrhages



Pale and Swollen Liver

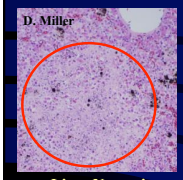
It attacks quickly killing hosts as fast as 3 days!

Hoverman et al. (2011a)

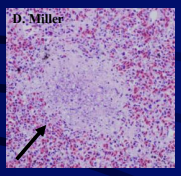
Organ Destruction

3 Primary Organs: Liver, Spleen, and Kidney

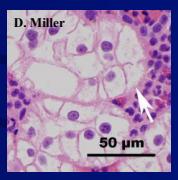
Bollinger et al. (1999)
Miller et al. (2007, 2008, 2011)



Liver Necrosis



Spleen Necrosis



Kidney Degeneration

Pathogenesis

Target Organ Failure

Heart Failure
Toxicosis, Anemia

What if Ranaviruses were Pathogenic to Humans?

12 – 32 C
Chinchar (2002)

Monday

Fever

Wednesday

Hands, Feet, Legs Swollen

No Vertebrate Pathogen: Diversity of Hosts or Kills as Quickly

There is no Cure!

Friday

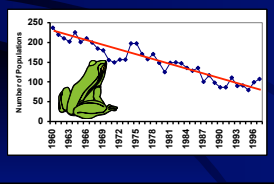
Bedridden, Body Enlarged 2X, Lesions, Hemorrhaging Internally and from Orifices

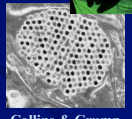
Sunday

Begging Dr. Death (Jack Kevorkian) for a quick end!

Are Ranaviruses Capable of Causing Local Extirpations and Species Declines?

Muths et al. (2006)





Collins & Crump (2009)

Traditional Theory
(Anderson and May 1979)

Extirpation is possible if:

Frequency Dependent

(1)Multiple Host Species Where Susceptibility Differs

- Asymptomatic Carriers

Is at least one of these conditions satisfied in the ranavirus-host system?

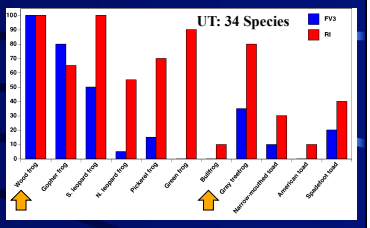
- Survive Outside Host

(3) Clustering of Individuals

- Sexually transmitted disease

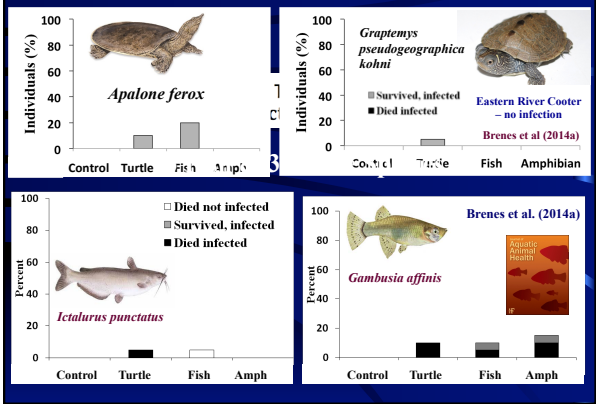
Evidence of Multiple Hosts
(Moody and Owens 1994, Marschang et al. 1999, 2005; Hyatt et al. 2002; Allender et al. 2006; Duffus et al. 2008, Picco et al. 2010; Hoverman et al. 2011a; Brenes 2013; Waltzek et al. 2015)

(1) Multiple-species Pathogen:



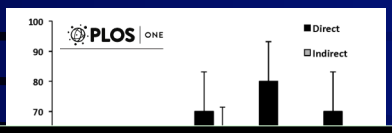
(2) Other Ectothermic Vertebrates

Evidence of Multiple Hosts

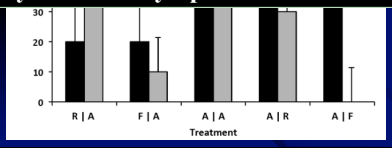


Evidence of Interclass Transmission

Brenes et al. (2014b)



Ranaviruses can infect multiple host species, transmission can occur between them, & some hosts may serve as asymptomatic carriers – #1 Met



Evidence of Environmental Persistence

(1) EHNV Persistence (Langdon 1989)

Ranaviruses can be remain viable outside the host for considerable duration (permanent wetlands at colder temperatures). – #2 Met

(2) FV3, FV3-like (Nazir et al. 2012)

Johnson & Brunner (2014) & Geng et al.
1 week at 20-25 C

20 C = •PW (unsterile): 22-34 d •Soil: 13-22 d

4 C = •PW (unsterile): 58-72 d •Soil: 30-48 d

(T-90 Values)

Evidence of Frequency Dependent Transmission

(1) Breeding (Brunner et al. 2004)

Frequency dependent transmission is possible in larval and adult age classes – #3 Likely.

(2) Larval Clustering

- Increase Contact Rates
- Vegetation Reduction

(Greer et al. 2008)

Local Extirpations and Declines?

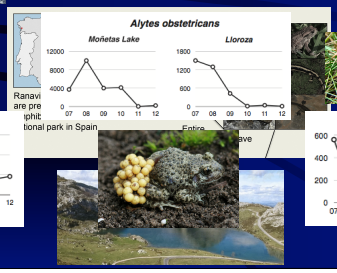
YES, all 3 characteristics met in the Ranavirus-Host System

Evidence of Local Extinction

Dr. Stephen Price
University College London
Picos de Europa National Park
2007-2012

Current Biology
24:2586-2591

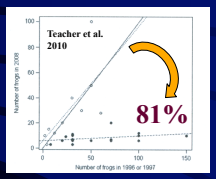
Ranavirus die-offs with six species



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

Evidence of Local Extinction

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

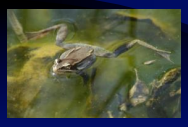
Biological Conservation
138:371-380

Wetlands
23:278-290

Recruitment at most wetlands failed due to ranavirus

Persistence Possible from Source Populations

Rescue Effect

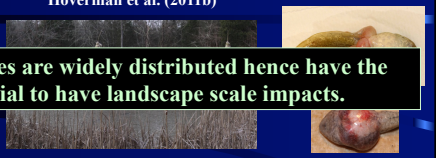


Earl et al. (in review): Immigration at natural levels may be insufficient

Ranavirus Landscape Prevalence

n = 40 ponds
2 years, 4 seasons

Tennessee Ponds
Hoverman et al. (2011b)



Ranaviruses are widely distributed hence have the potential to have landscape scale impacts.

Ranavirus Distribution: 83% of Ponds Sampled

Hotspots: ≥40% in 15 out of 40 Ponds Sampled

- 85% Infection
- 100% Infection (morbid and dead)

EcoHealth

EcoHealth 9:36-48

Cry Wolf or Valid Risk?

Should we be Concerned?

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

Epidemiological Theory, Modest Field Data, AND Initial Simulations (next) 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.

Questions??

Photo: M. Niemiller

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FUTURE