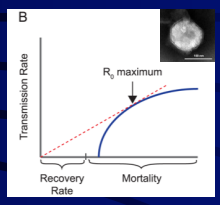
Captivity-induced Evolution:
Role of Humans in Modifying Virulence



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

Outline

I. Virulence Evolution

II. Captive Isolates

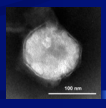
III. Conservation Implications

Required Reading: Bull JJ, Lauring AS (2014) Theory and Empiricism in Virulence Evolution. PLoS Pathog 10(10): e1004387. doi:10.1371/journal.ppat.1004387

Supplemental Reading: Alizon S, Hurford A, Mideo N, Van Baalen M (2009) Virulence evolution and the trade-off hypothesis: history, current state of affairs and the future. Journal of Evolutionary Biology, 22: 245–259. doi: 10.1111/j.1420-9101.2008.01658.x

Pathogen Virulence

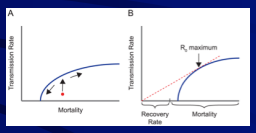
Alizon et al. (2009), Bull and Lauring (2014)



Virulence:

- Increase in death rate of the host due to the pathogen
  - Evade host immune system
  - Replication rate
  - Transmission rate

Pathogenicity?



Two Hypotheses:

- Trade-off:
  - Evolution toward low to intermediate virulence
- Short-sighted Evolution:
  - Evolution toward high virulence
  - Rapid replication and transmission

When would you expect evolution to be favored for increased virulence?

Captive Conditions

https://www.youtube.com/watch?v=f2q5jqdsTeA

The perfect cauldron for virulence evolution!

- Hosts
- Strains
- Immunocompromised

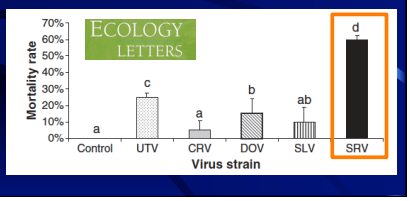
First Evidence

Majji et al. (2006)

DISEASES OF AQUATIC ORGANISMS

Expt	FV3	RCV-Z	MEM
1	1/10 (10%)	10/10 (100%)	0/10 (0%)
2	0/10 (0%)	5/10 (50%)	0/10 (0%)

Storfer et al. (2007)



Bullfrog Die-off: Alapaha, GA

EMERGING INFECTIOUS DISEASES

The University of Georgia

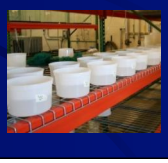
Volume 13, Number 2—February 2007

Miller et al. (2007)

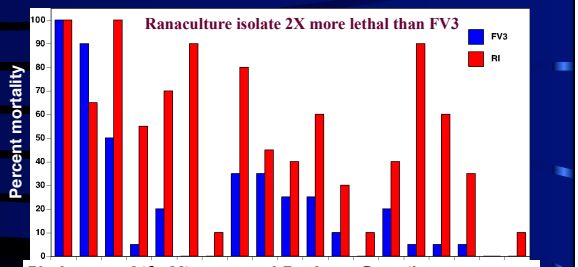
Letter

Frog Virus 3 Infection, Cultured American Bullfrogs

The FUTURE of Veterinary Medicine



Trends in Susceptibility



Phylogeny, Life History, and Ecology Contribute to Differences in Amphibian Susceptibility to Ranaviruses

Jason T. Hoverman,[1,2] Matthew J. Gray,[2] Nathan A. Haislip,[2,4] and Debra L. Miller[2,3,5]

EcoHealth

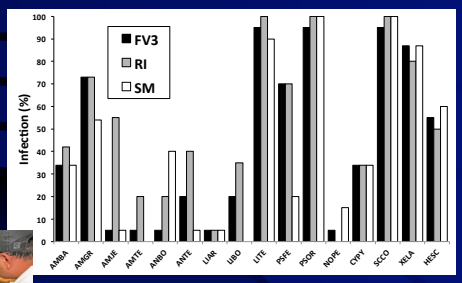
Hoverman et al. (2011a): 19 Species Tested

Single-species FV3-like Challenges

16 Additional Species

Amphibians

Brenes (2013): UT Dissertation



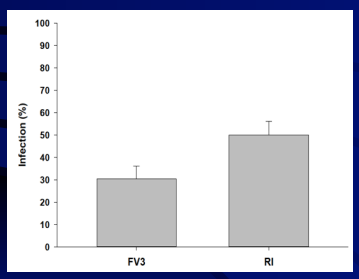
Total: RI > FV3 25/35 = 71%; RI>SM for 7 spp

Single-species FV3-like Challenges

35 Species

Amphibians

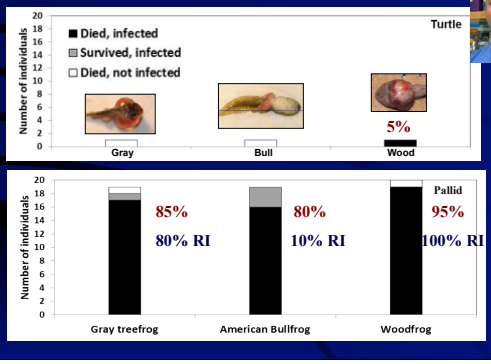
Brenes (2013)



Another FV3-like Isolate from Captivity

0% mortality in controls

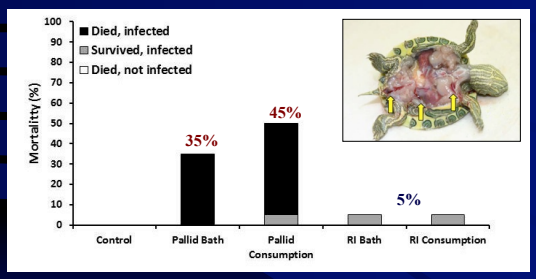
Waltzek, Gray, and Miller



Pallid vs. GA Bullfrog Isolate

0% mortality in controls

Waltzek, Gray, and Miller



Pallid Isolate Caused Mortality; Bullfrog Isolate Resulted in Infection

Multiple Captive Isolates

Geng, Gray, Waltzek, Une, and Miller

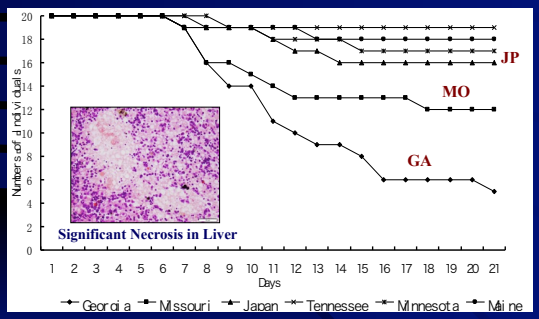
Lithobates clamitans (green frog)

Lithobates catesbeianus (American bullfrog)

Six Isolates: Captive = GA bullfrog, MO pallid
Wild = TN, MN, and ME
Pseudo-wild = Japan (Am. Bullfrog)

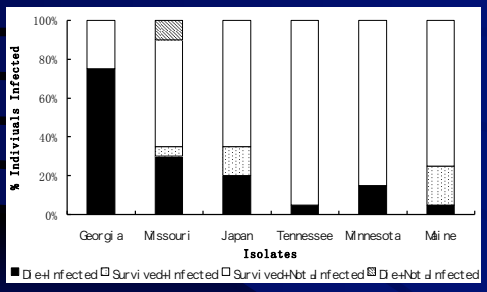
Survival Curves

Green Frogs



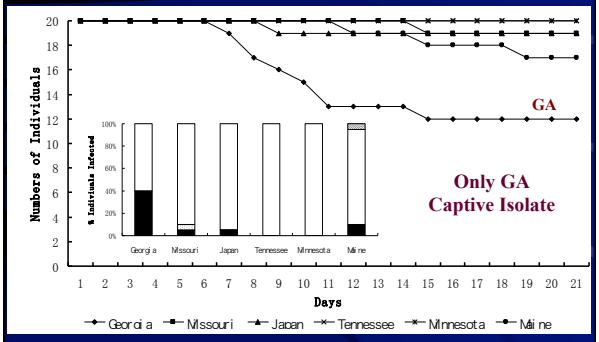
Final Mortality & Infection

Green Frog



Survival & Infection

American Bullfrog



Risk of Pathogen Pollution

Majji et al. (2006), Storfer et al. (2007), Mazzoni et al. (2009), Hoverman et al. (2011a), Brenes (2013)

Conservation Implications

Kristine Smith, DVM

From 2000-2006, the U.S. imported >1.5 billion individual animals (fish & wildlife; Smith et al. 2009)

- 90% fish, 2% amphibians, 1% reptiles
- 25 million live amphibians imported to U.S./year

Ranavirus Positive

- Hong Kong = 89%
- Dominican Republic = 70%
- Madagascar = 57%

Smith et al. (unpubl. data)

Questions??

Photo:
N. Wheelwright

mgray11@utk.edu
+1-865-974-2740