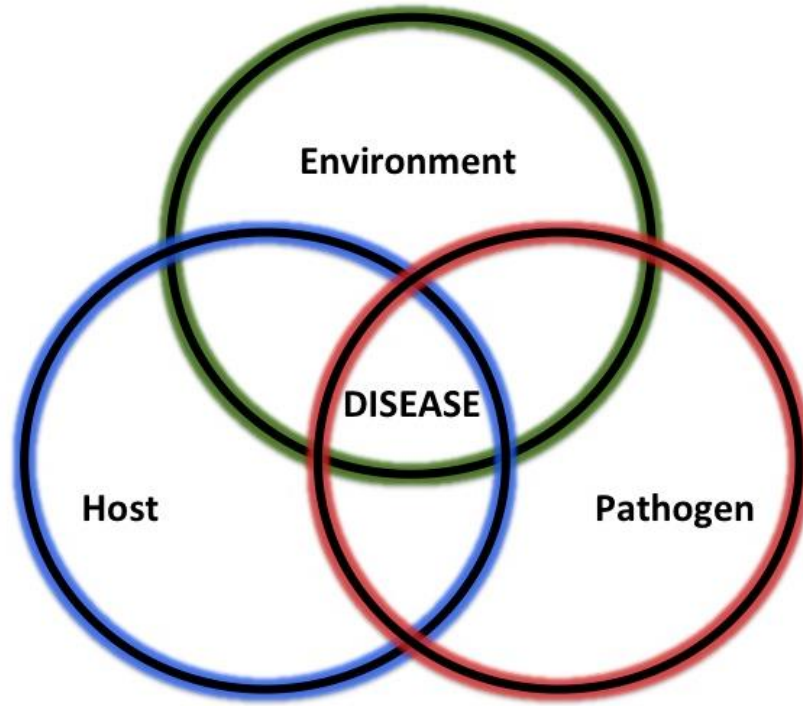




Shifts in Disease Dynamics in a Tropical Amphibian Assemblage Are Not Due to Pathogen Attenuation

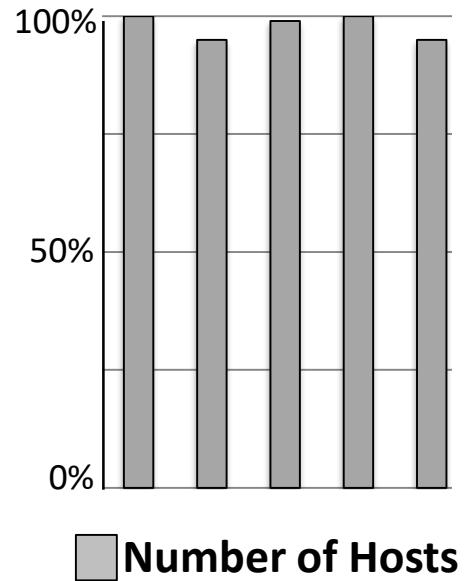
Jamie Voyles
University of Nevada, Reno



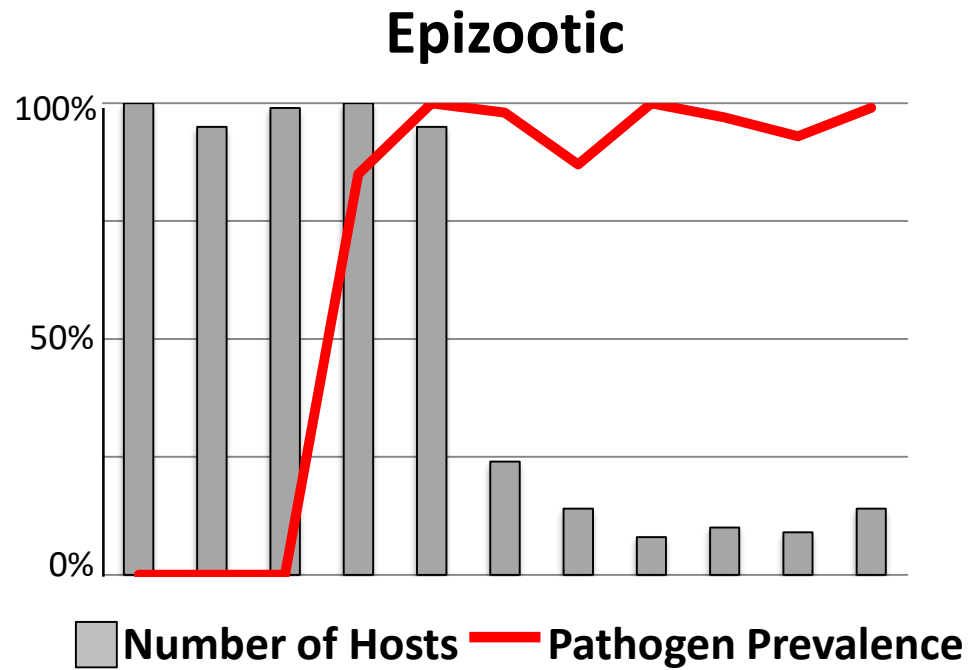
Disease: a dynamic interaction that depends on the host, the pathogen and their shared environment.

Disease rarely ends in host extinction

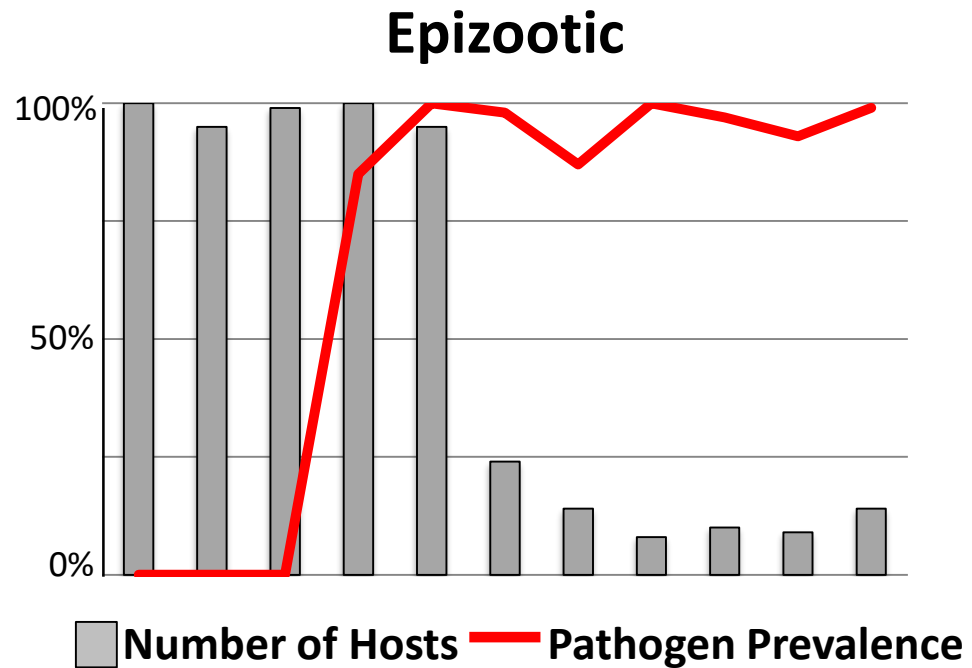
Disease rarely ends in host extinction



Disease rarely ends in host extinction

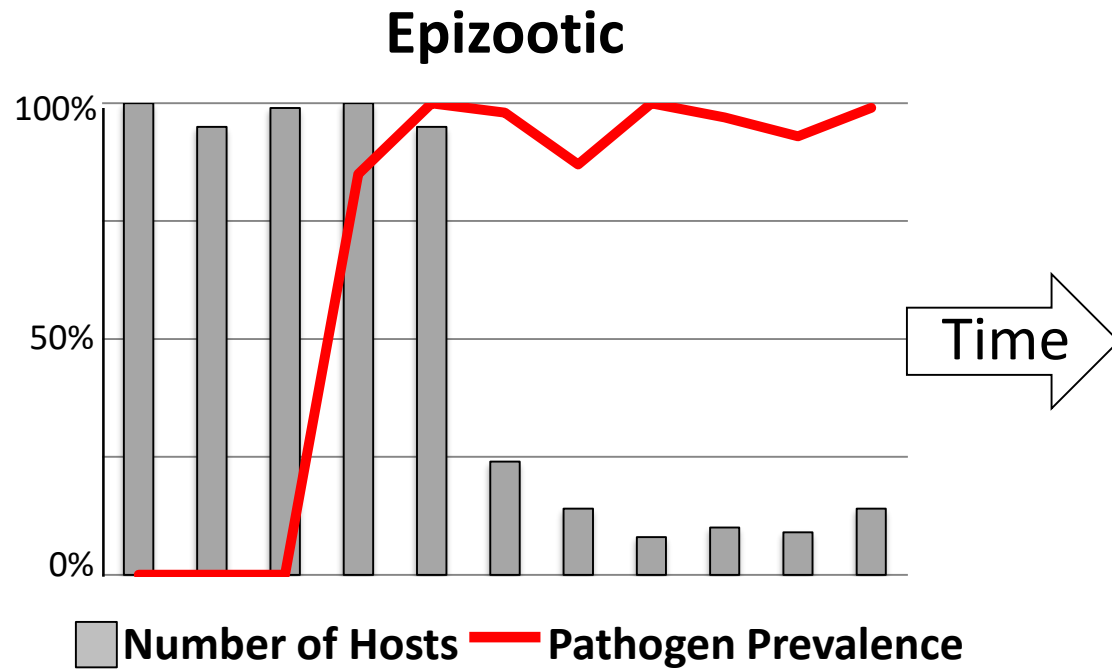


Disease rarely ends in host extinction

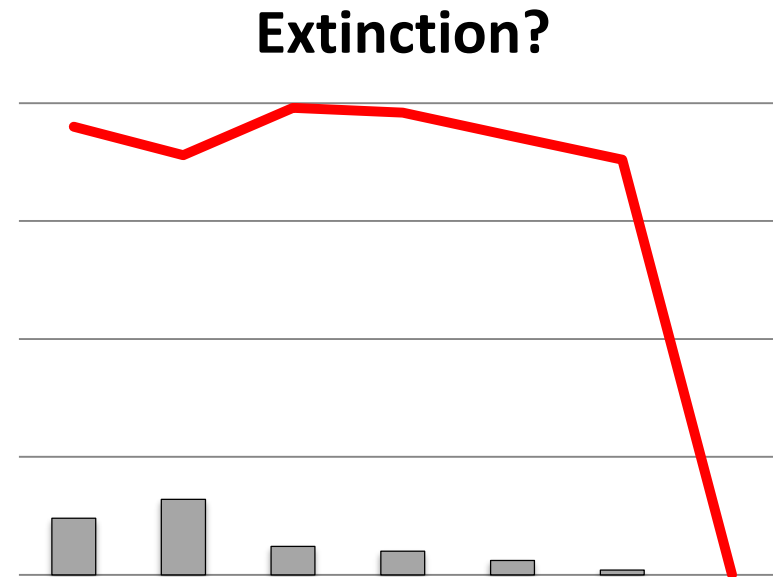
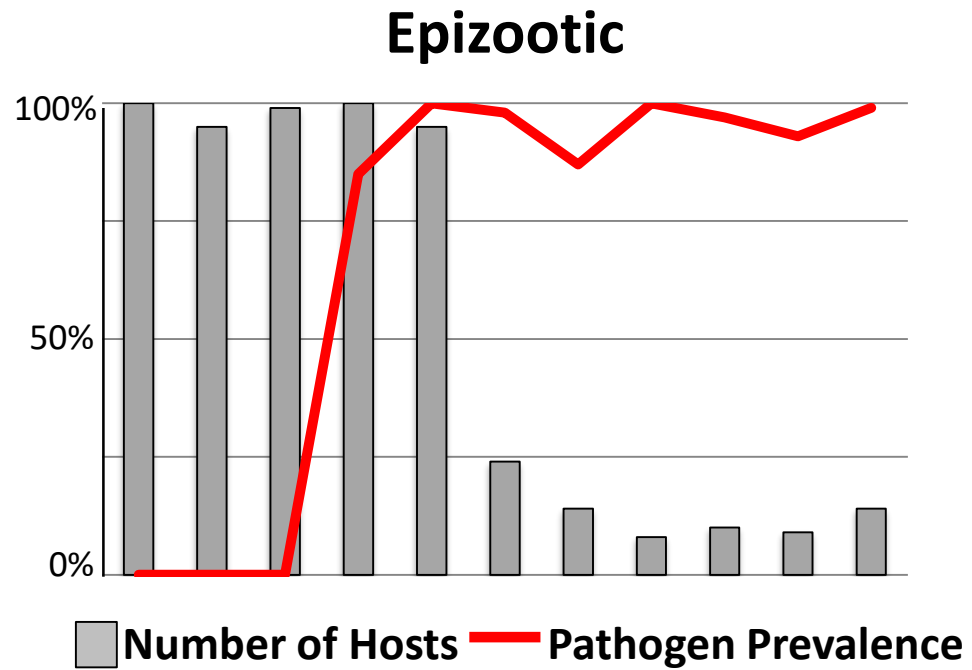


Epizootic- phase of rapid increase in pathogen prevalence and spread of disease in wildlife hosts

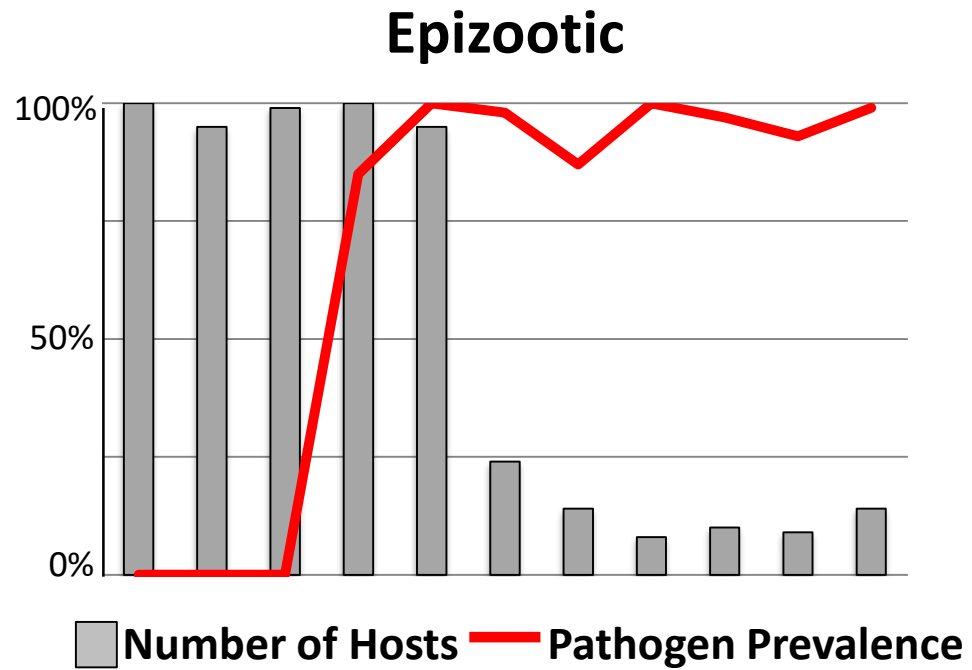
Disease rarely ends in host extinction



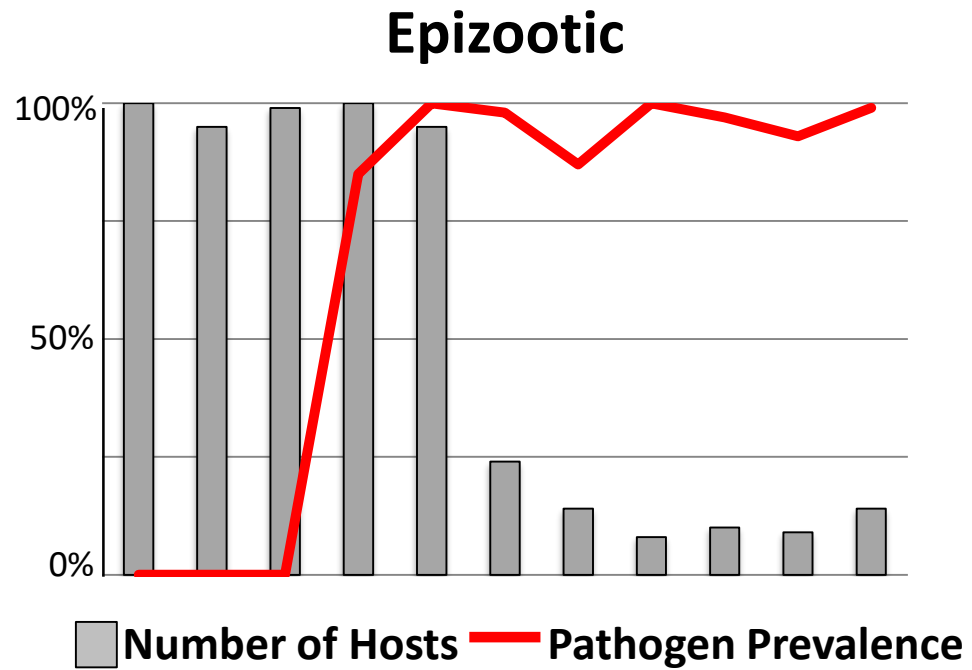
Disease rarely ends in host extinction



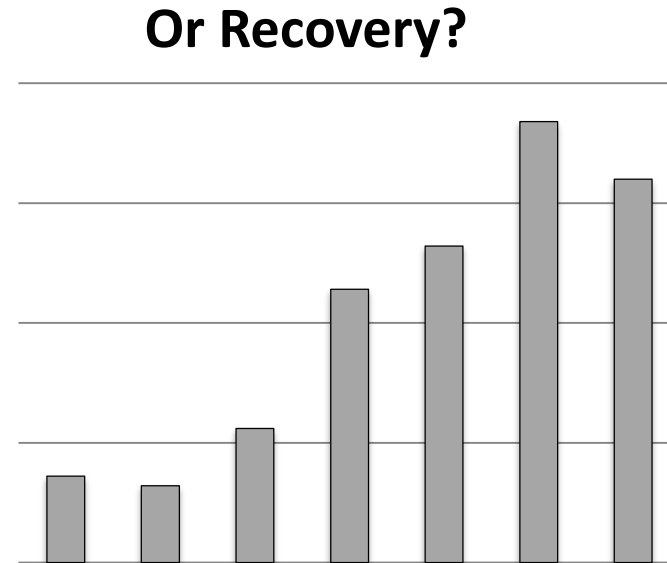
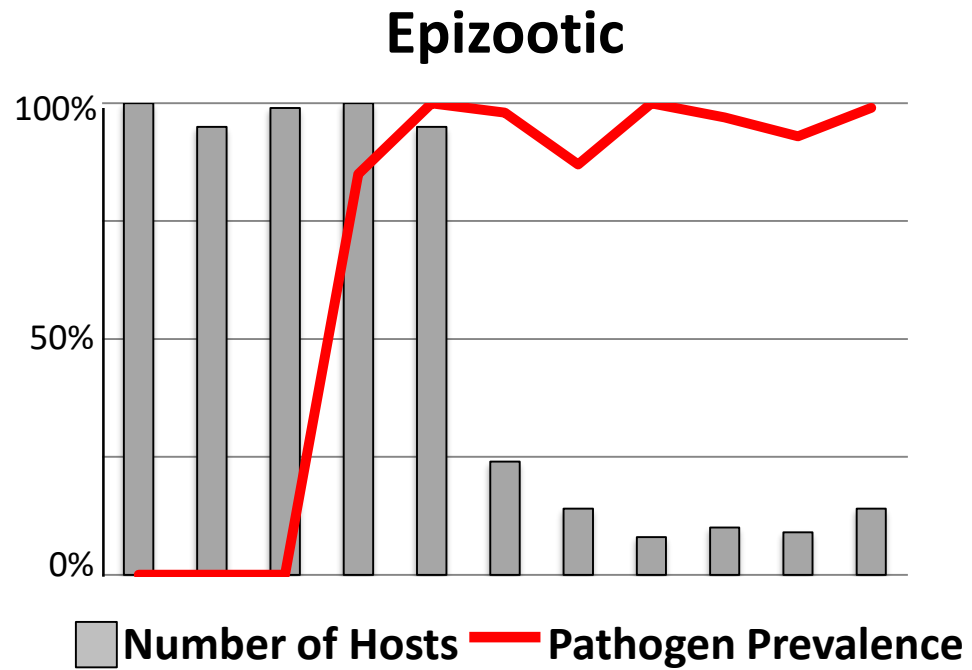
Disease rarely ends in host extinction



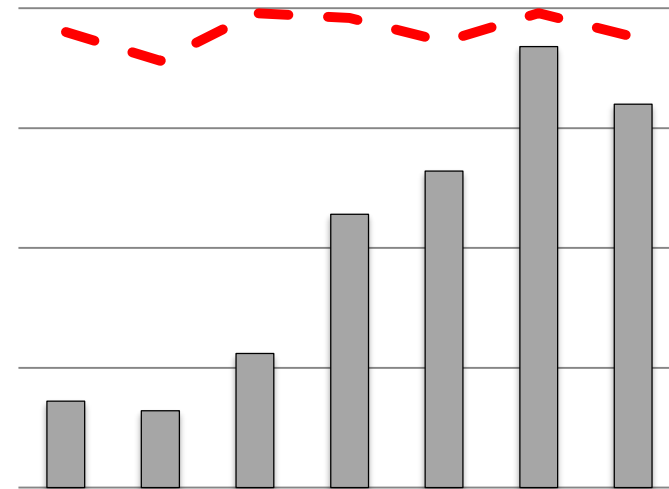
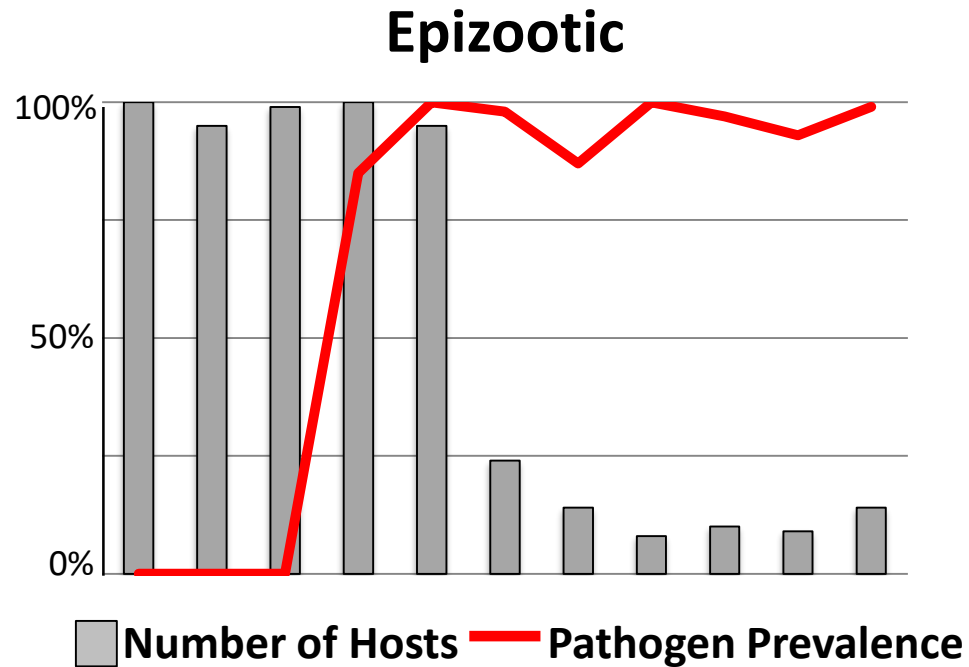
Disease rarely ends in host extinction



Disease rarely ends in host extinction

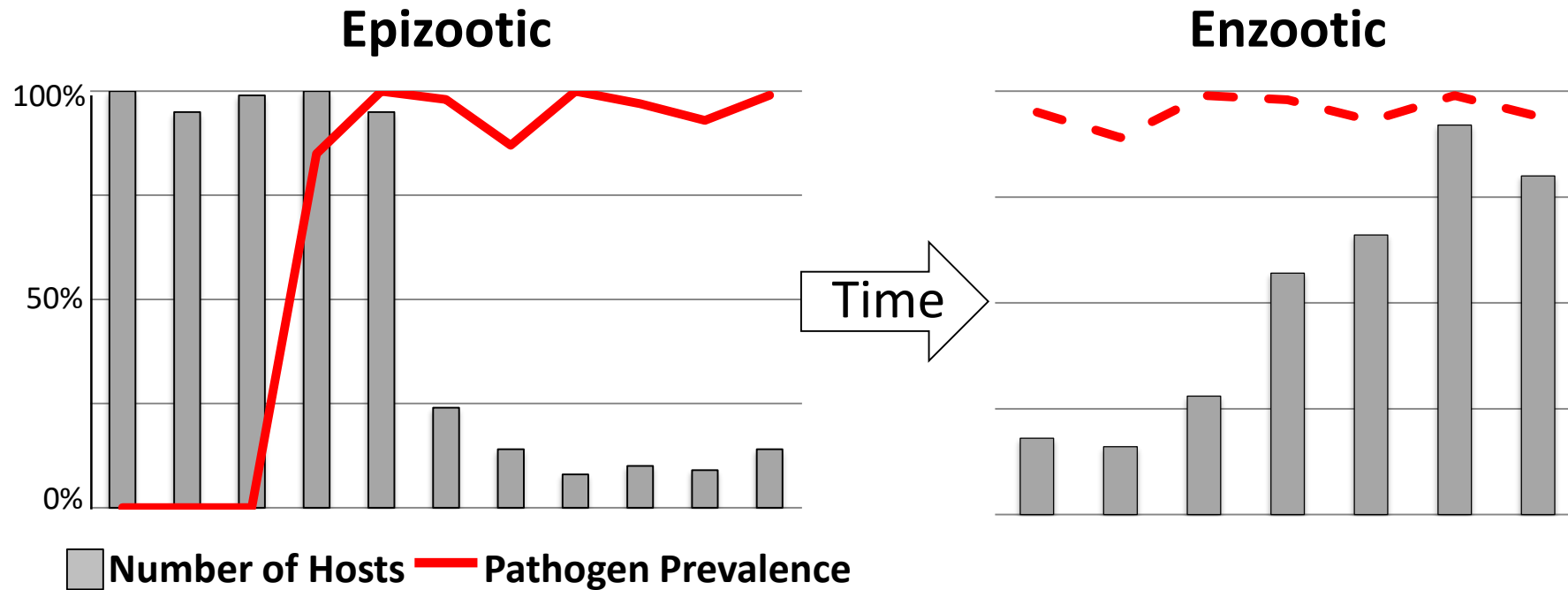


Disease rarely ends in host extinction



Enzootic- phase where the pathogen is constantly present but disease only occurs in a small number of hosts.

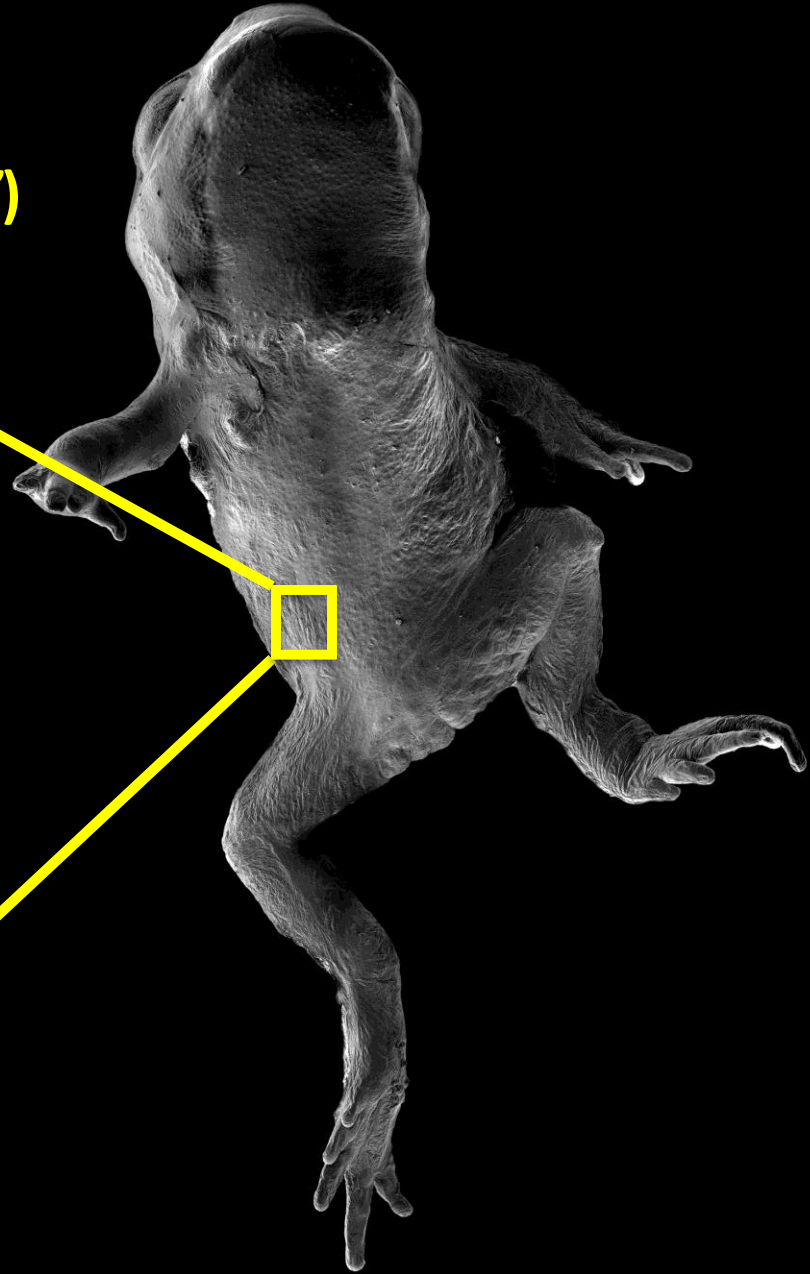
Disease rarely ends in host extinction



Chytridiomycosis
***Batrachochytrium dendrobatidis* ("Bd")**



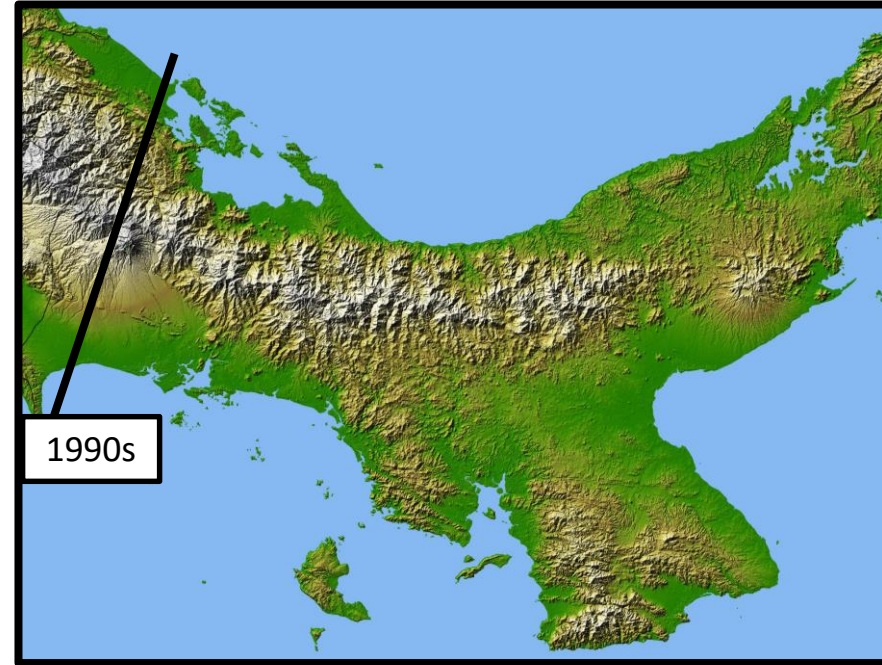
Chytridiomycosis
***Batrachochytrium dendrobatidis* ("Bd")**



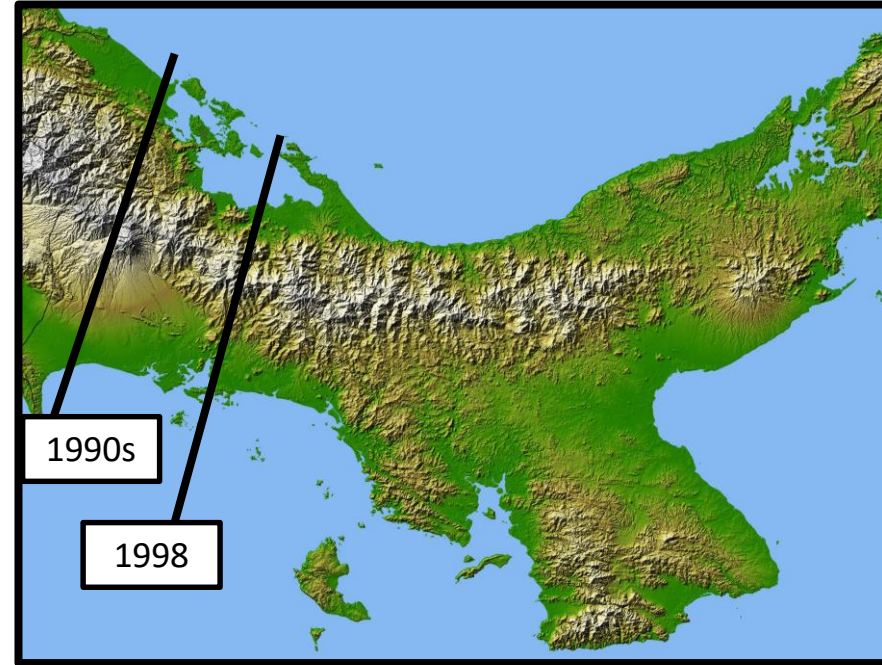
Amphibian Declines in Western Panama



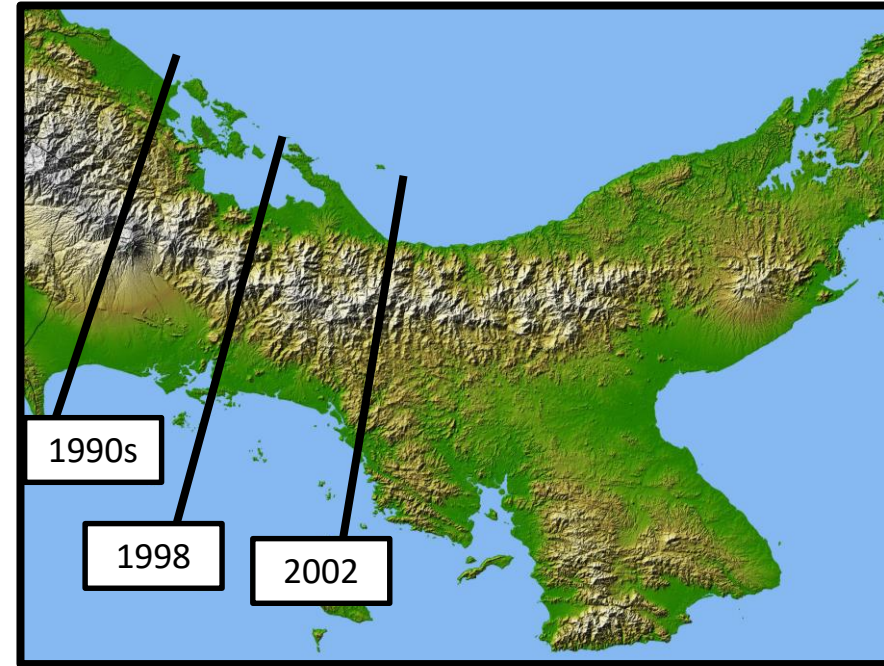
Amphibian Declines in Western Panama



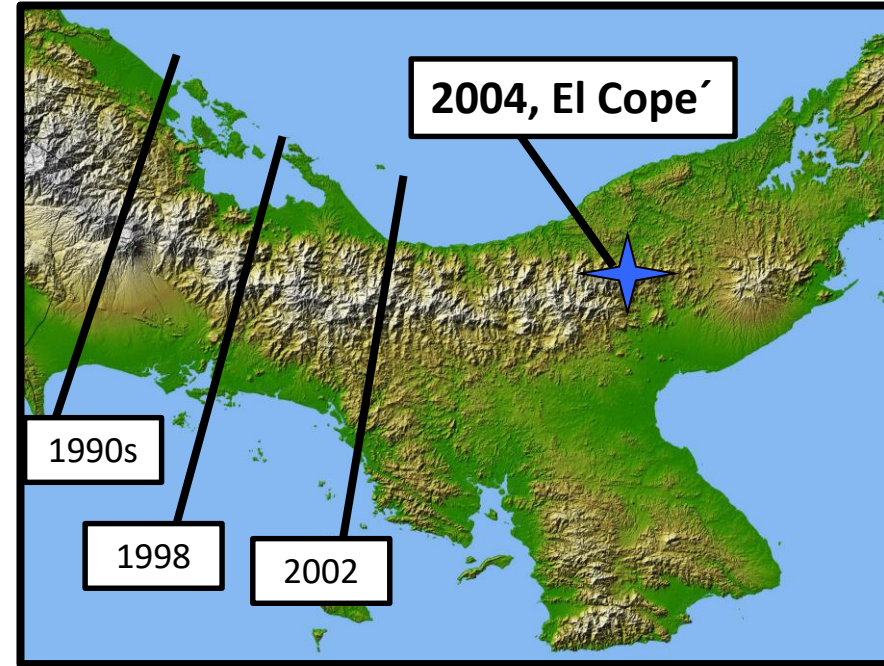
Amphibian Declines in Western Panama



Amphibian Declines in Western Panama



Amphibian Declines in Western Panama



Panama in 2004

High species diversity

High abundance



Panama in 2004

High species diversity

High abundance



Panama in 2004

High species diversity

High abundance



Two objectives

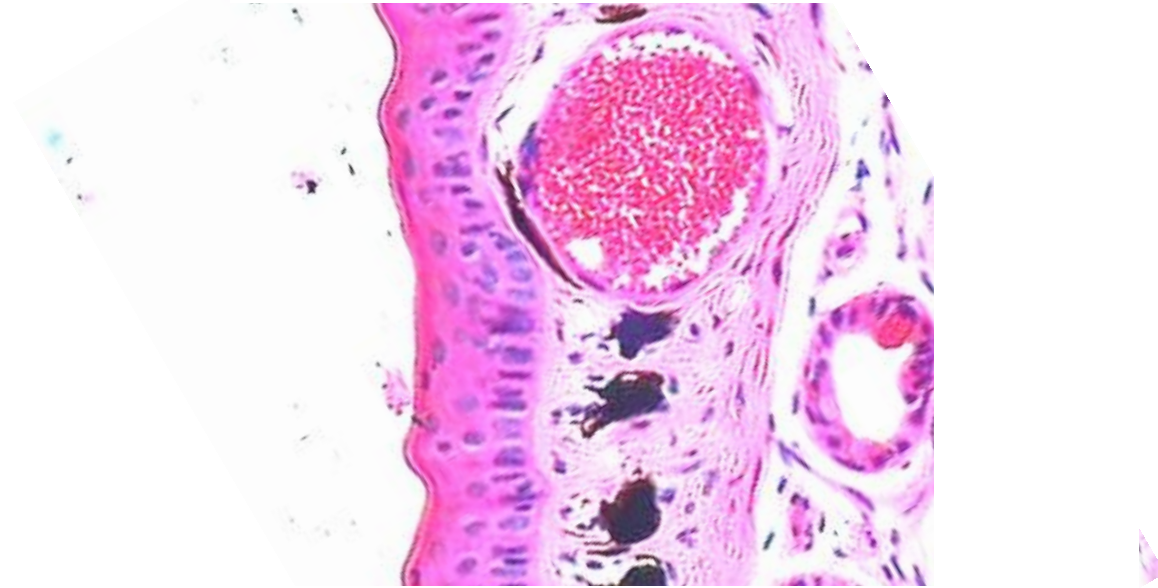
1. Screen for disease
2. Profile immune defenses

Amphibian skin:
Provides critical immune defenses

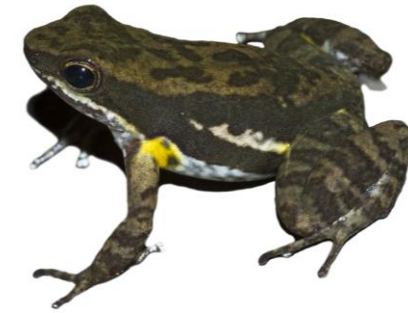


epidermis

dermis



Amphibian skin:
Provides critical immune defenses

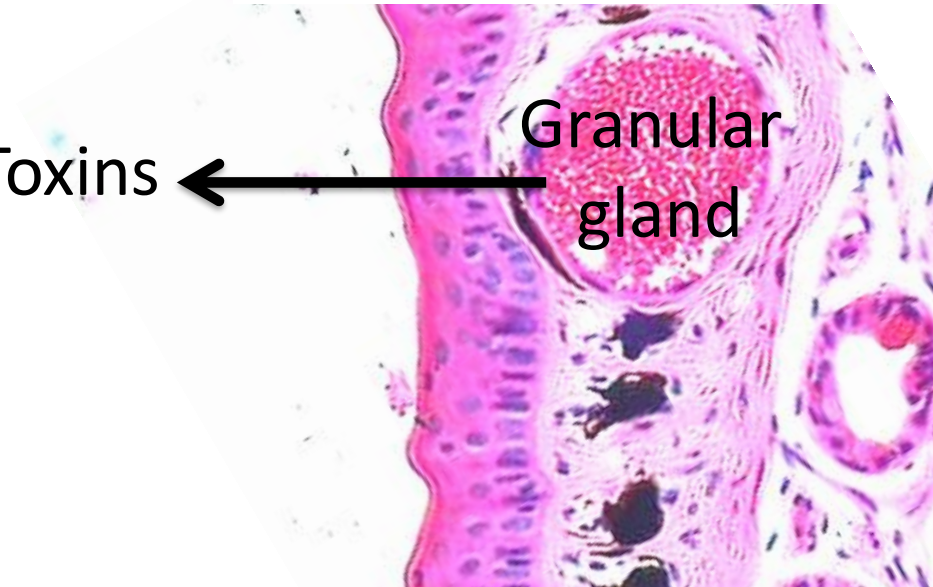


epidermis

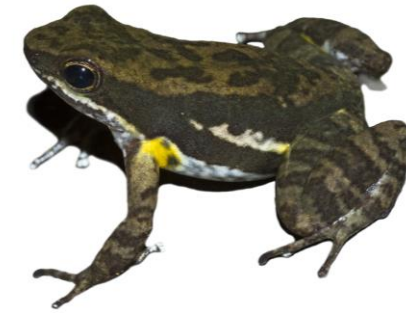
dermis

Toxins

Granular
gland



Amphibian skin: Provides critical immune defenses



epidermis

dermis

-Skin secretions from granular glands provide non-specific defenses against cutaneous pathogens



Granular
gland

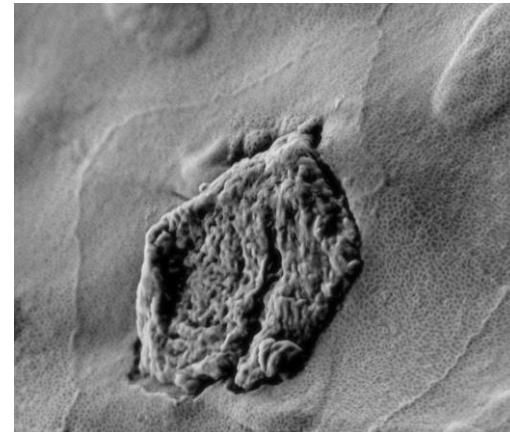
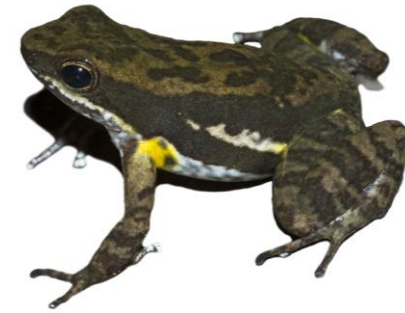
Amphibian skin: Provides critical immune defenses

-Skin secretions from granular glands provide non-specific defenses against cutaneous pathogens



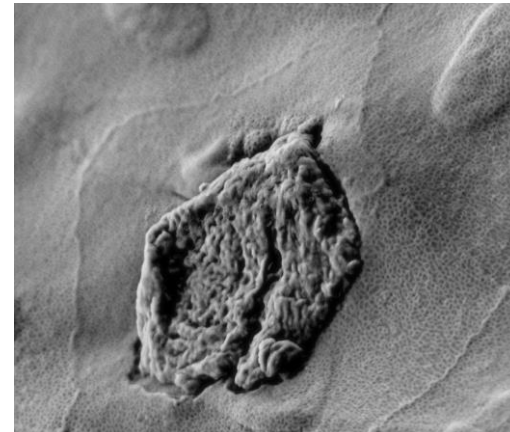
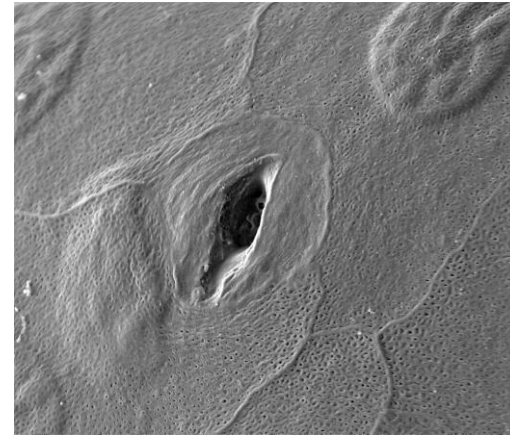
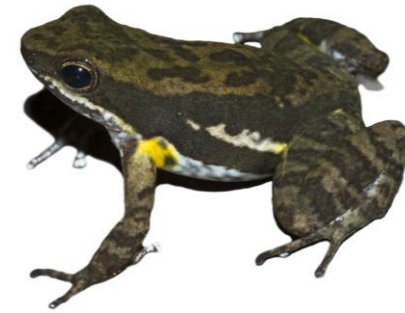
Amphibian skin: Provides critical immune defenses

-Skin secretions from granular glands provide non-specific defenses against cutaneous pathogens



Amphibian skin: Provides critical immune defenses

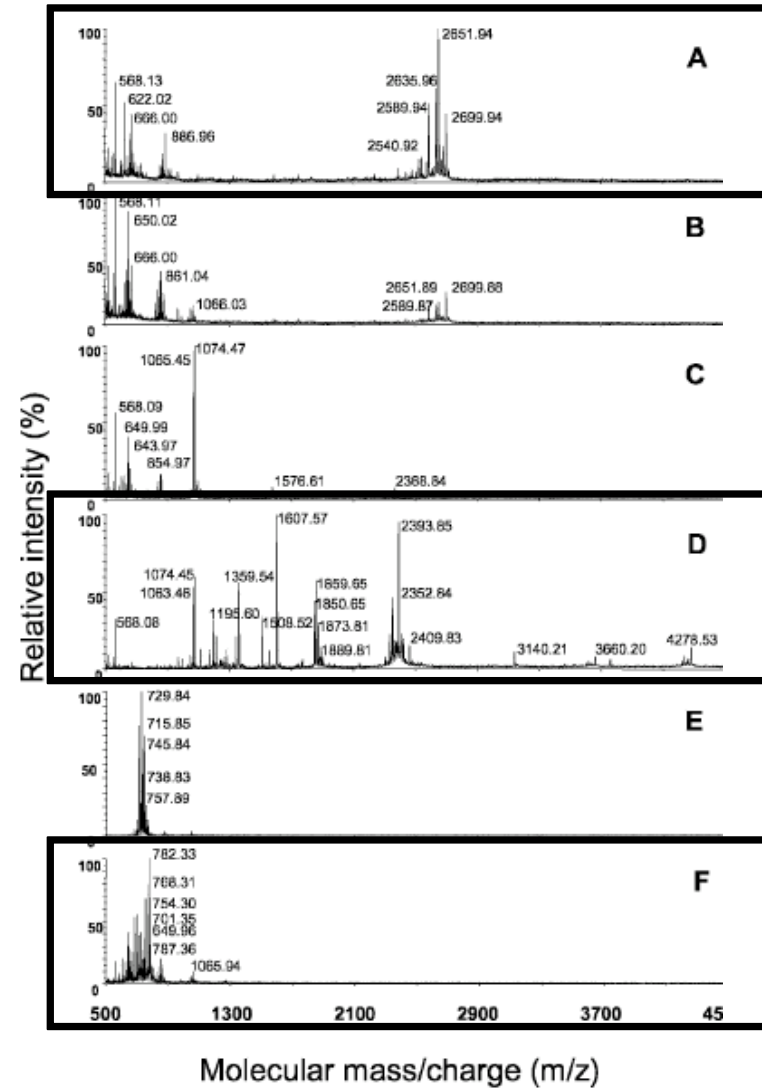
- Skin secretions from granular glands provide non-specific defenses against cutaneous pathogens
- Secretions contain antimicrobial peptides (AMPs) that differ among species



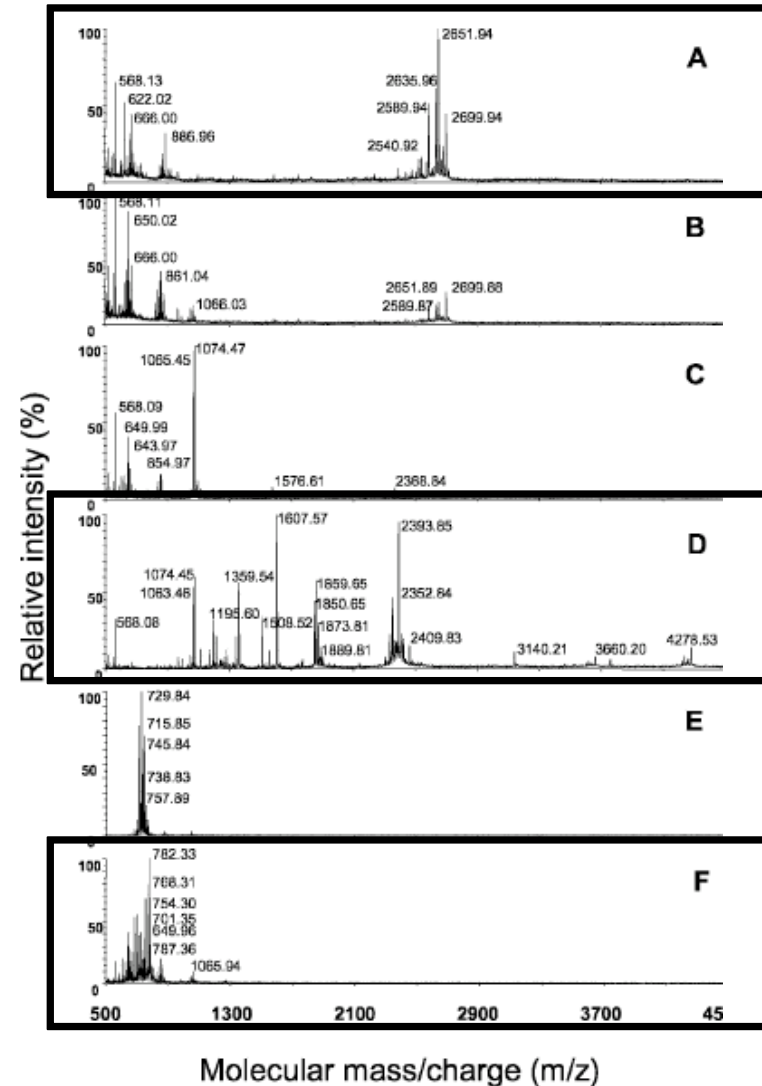
Frog defenses: skin secretions



Frog defenses: skin secretions

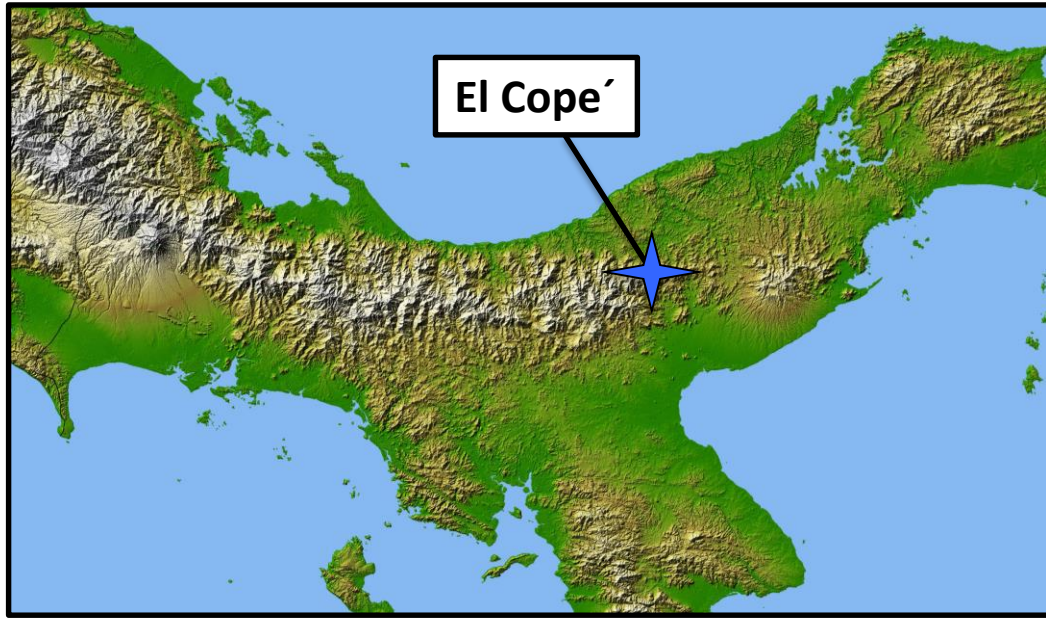


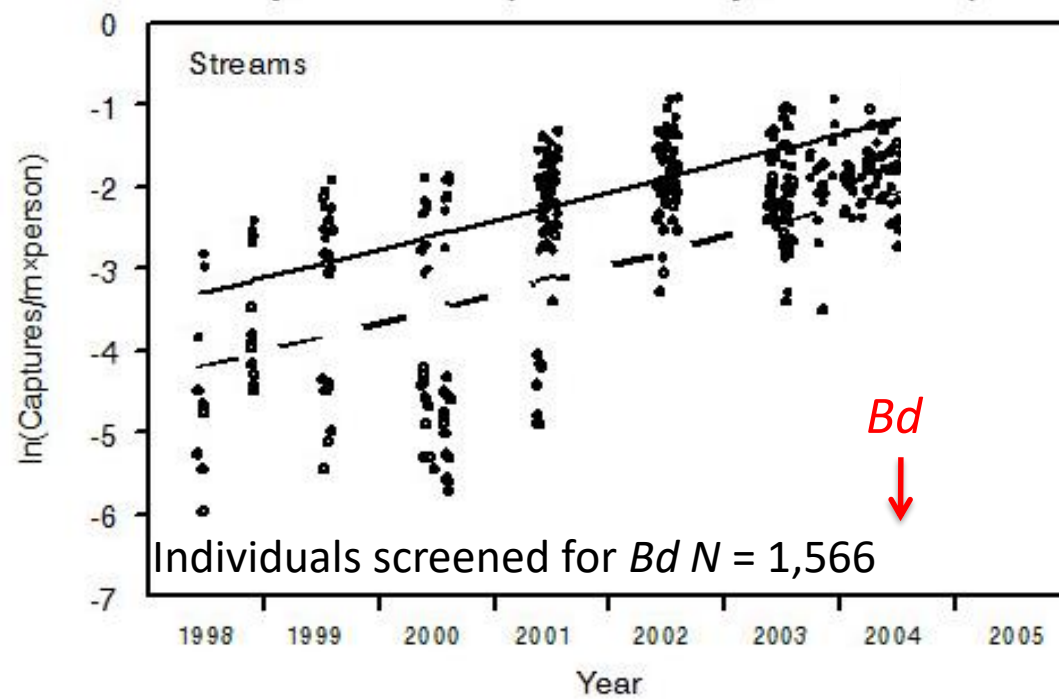
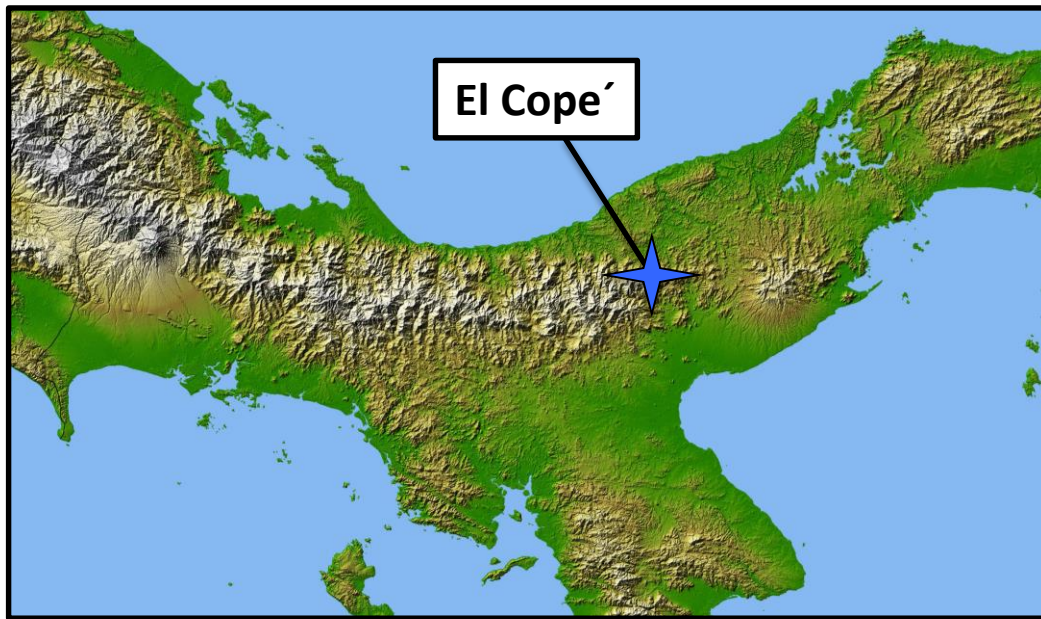
Frog defenses: skin secretions

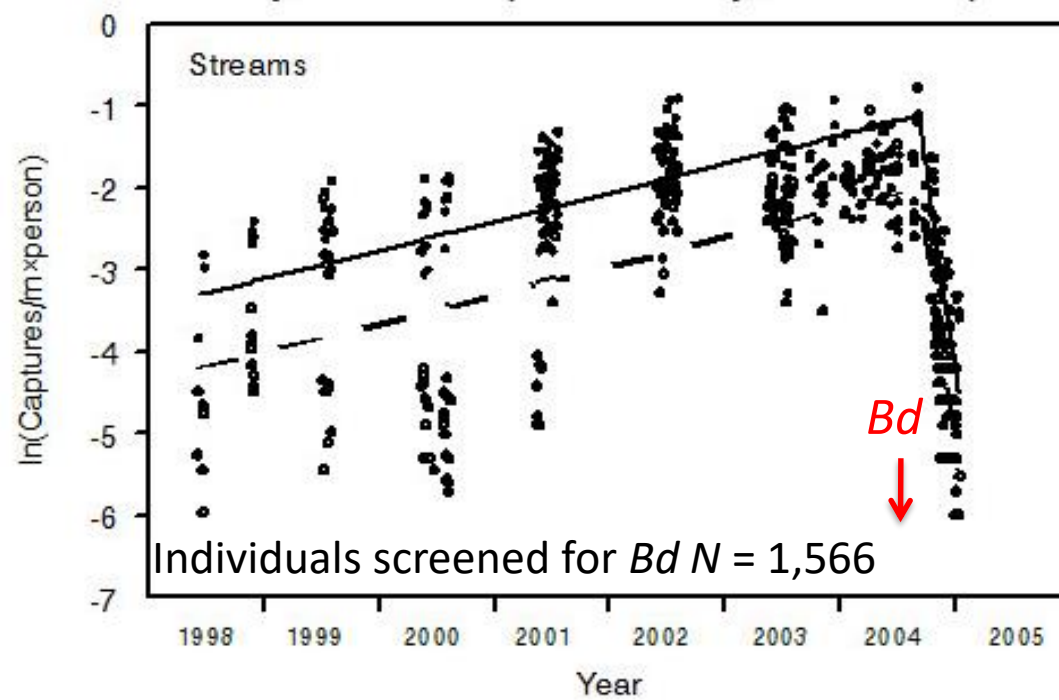
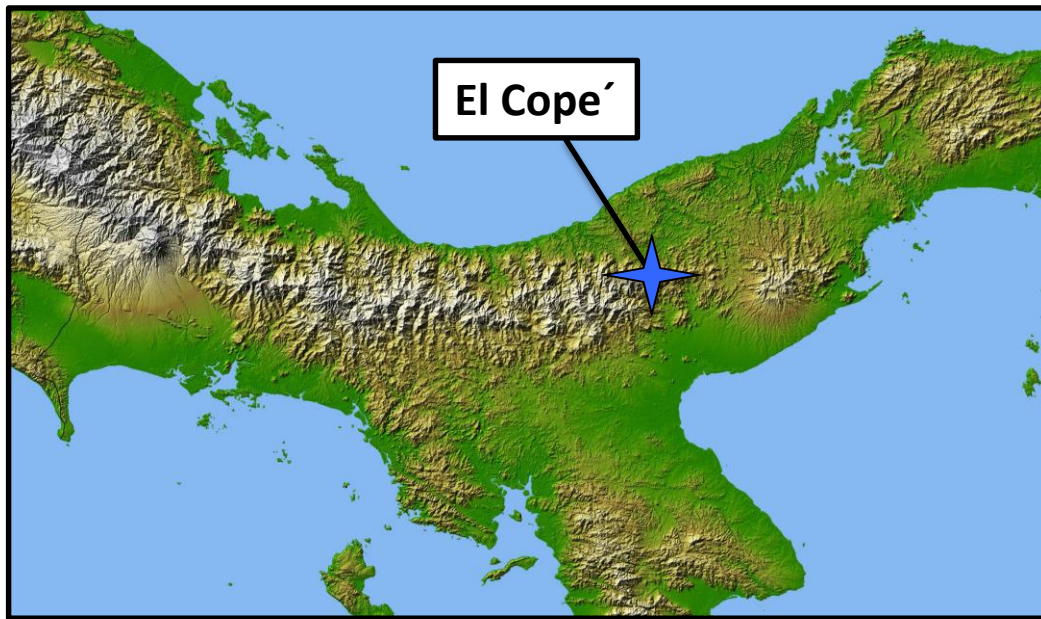


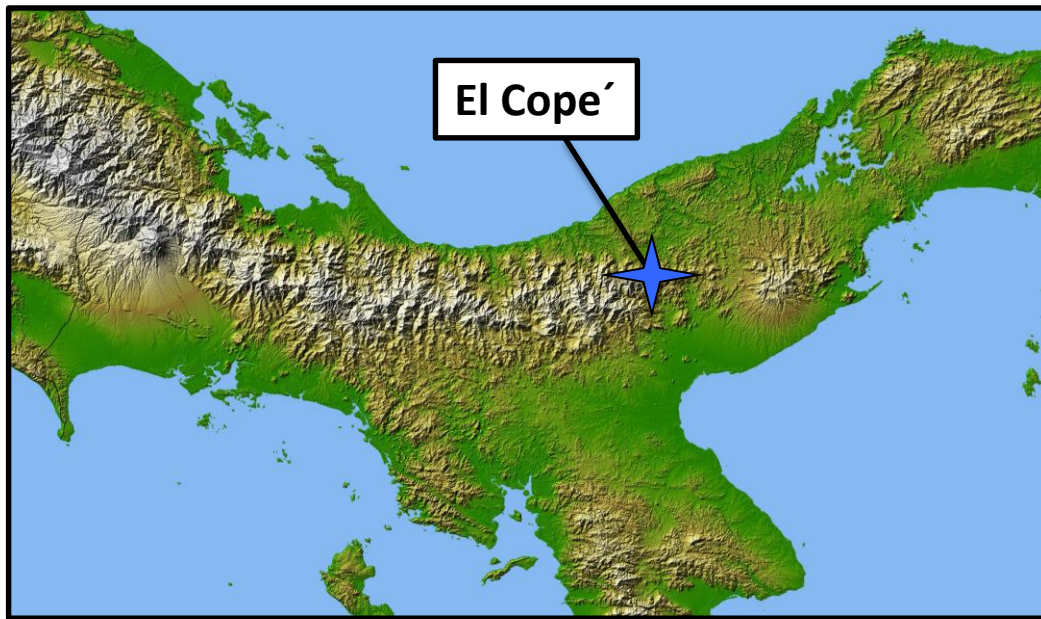
Challenge
assay

Test for
inhibition
of pathogens

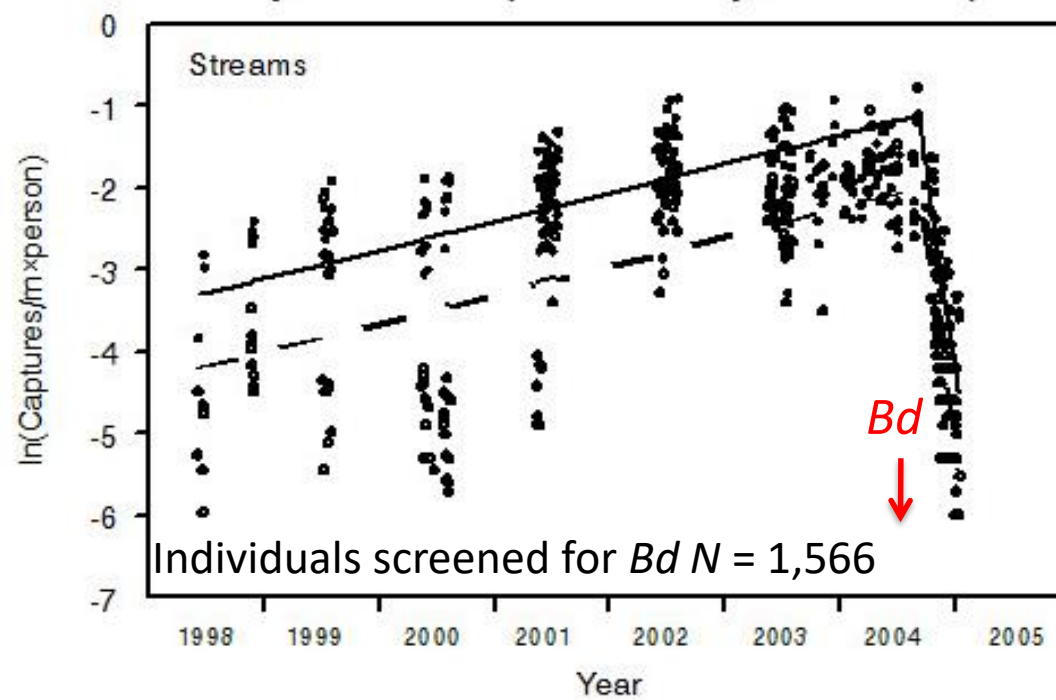


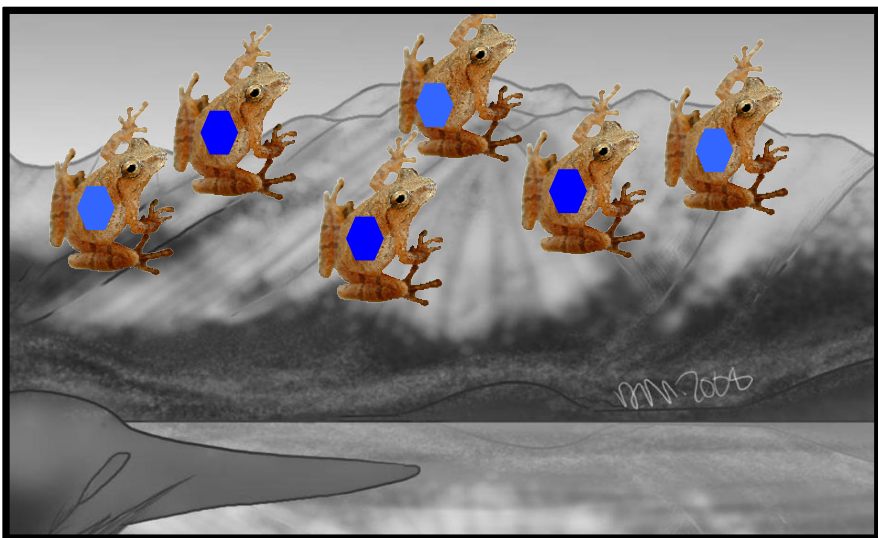




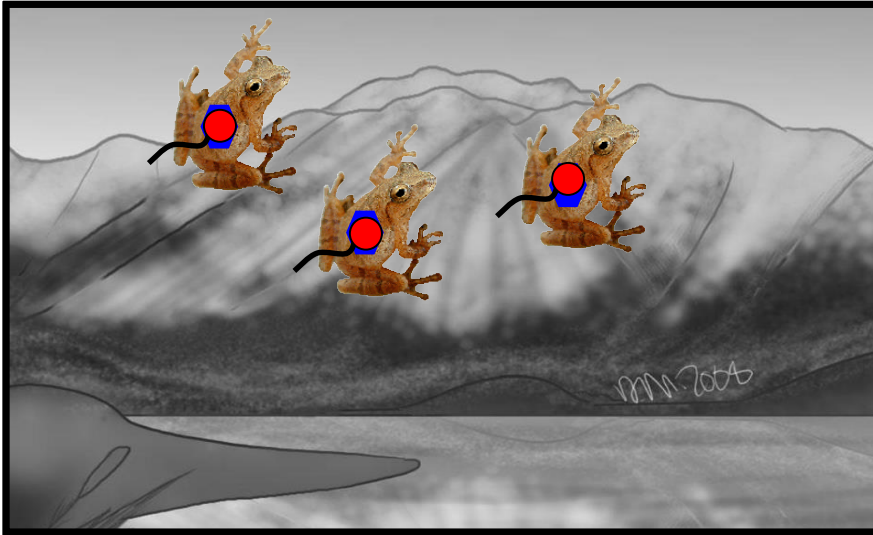


Photos: R Brenes

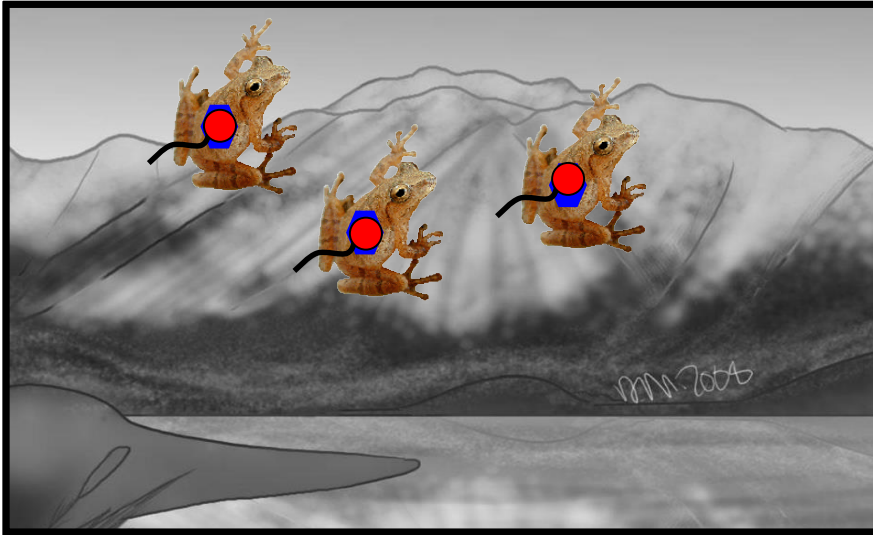




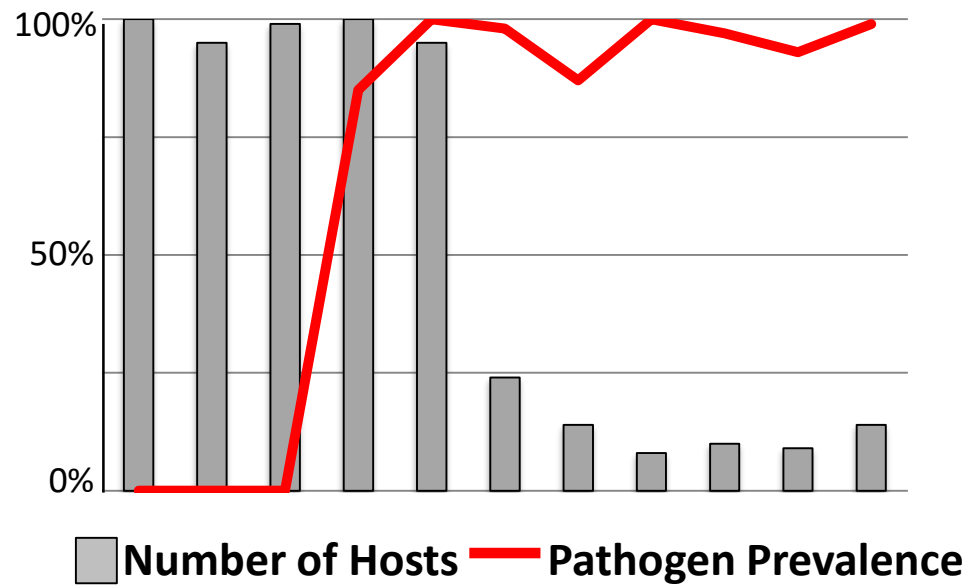
🐍 - Highly pathogenic *Bd*



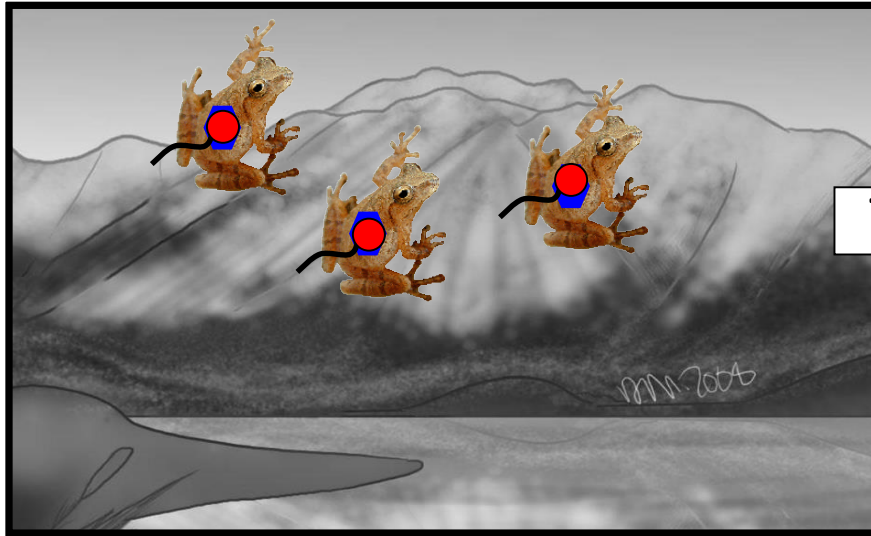
🐍● - Highly pathogenic *Bd*



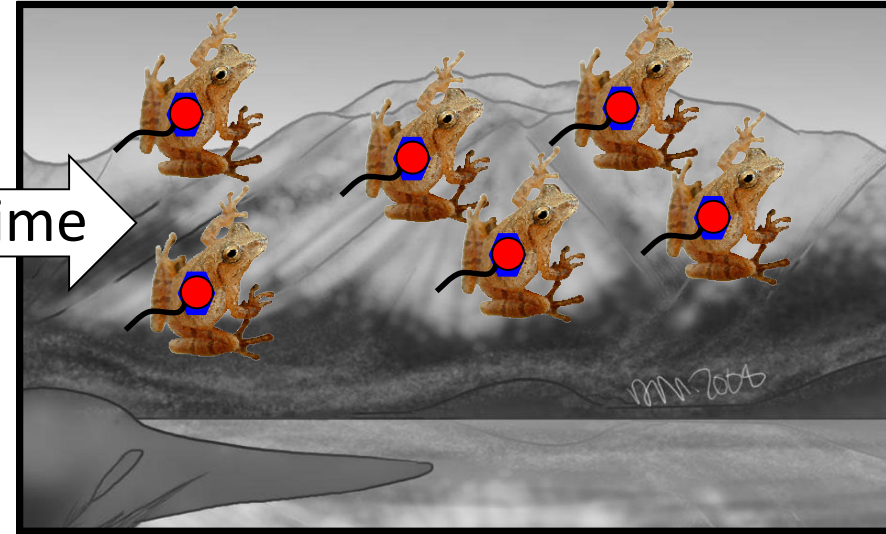
2004



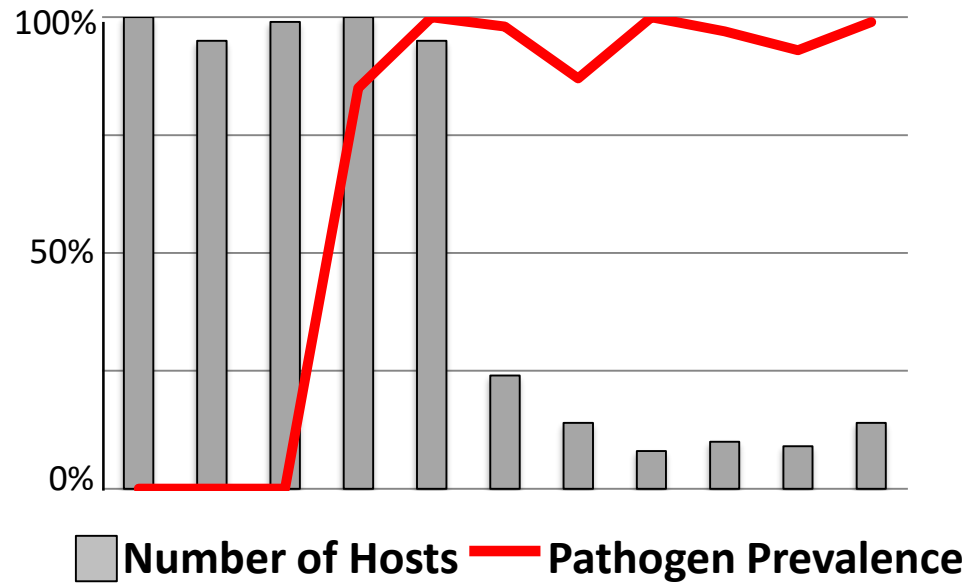
🐍● - Highly pathogenic *Bd*



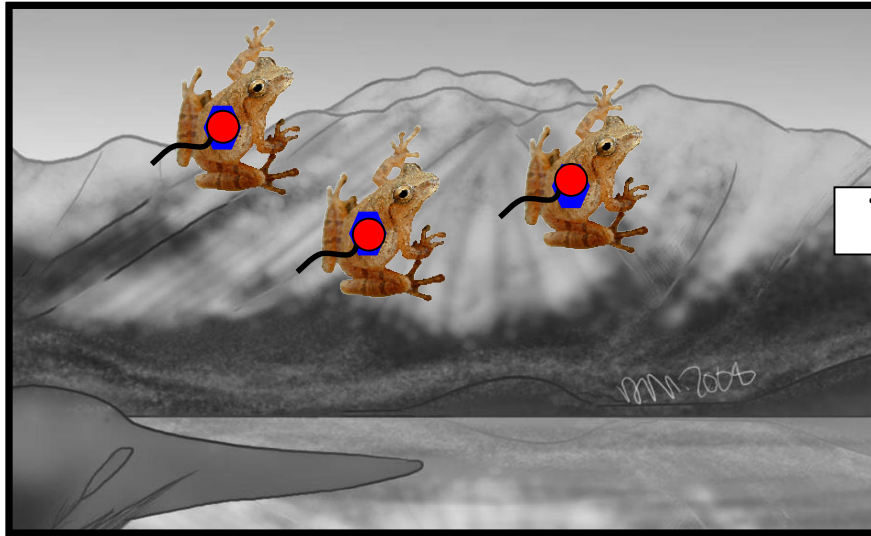
2004



2017



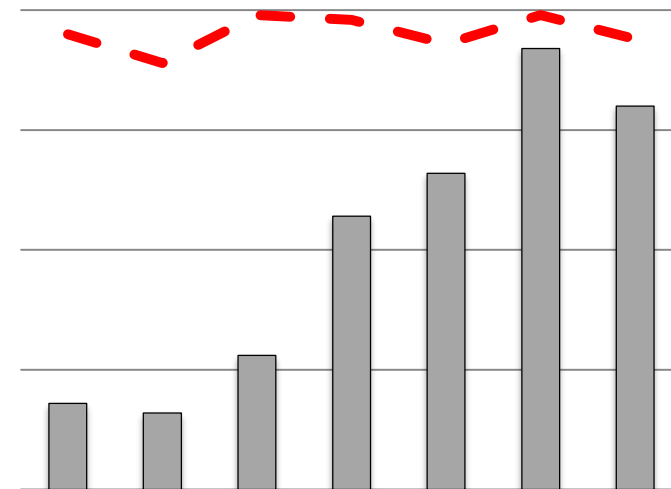
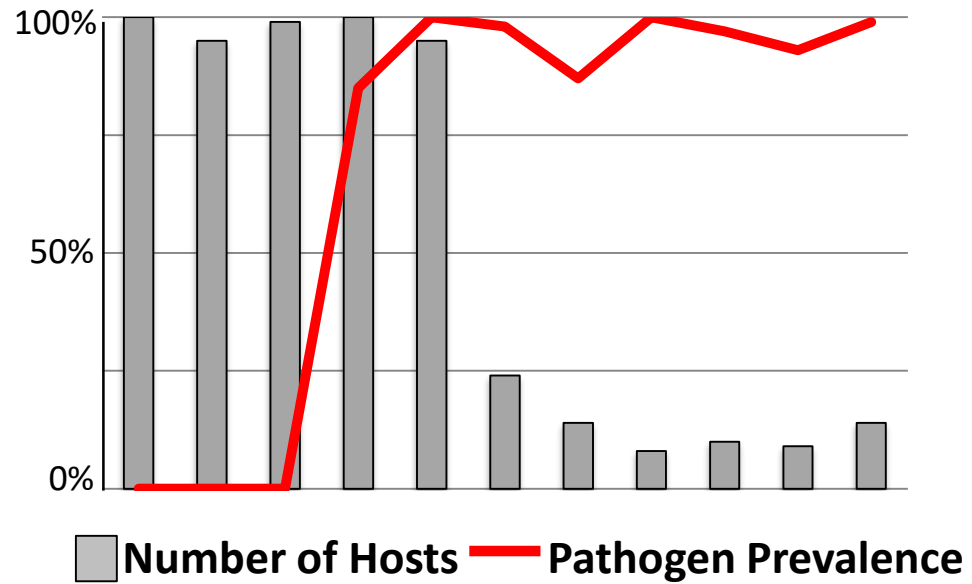
~● - Highly pathogenic *Bd*

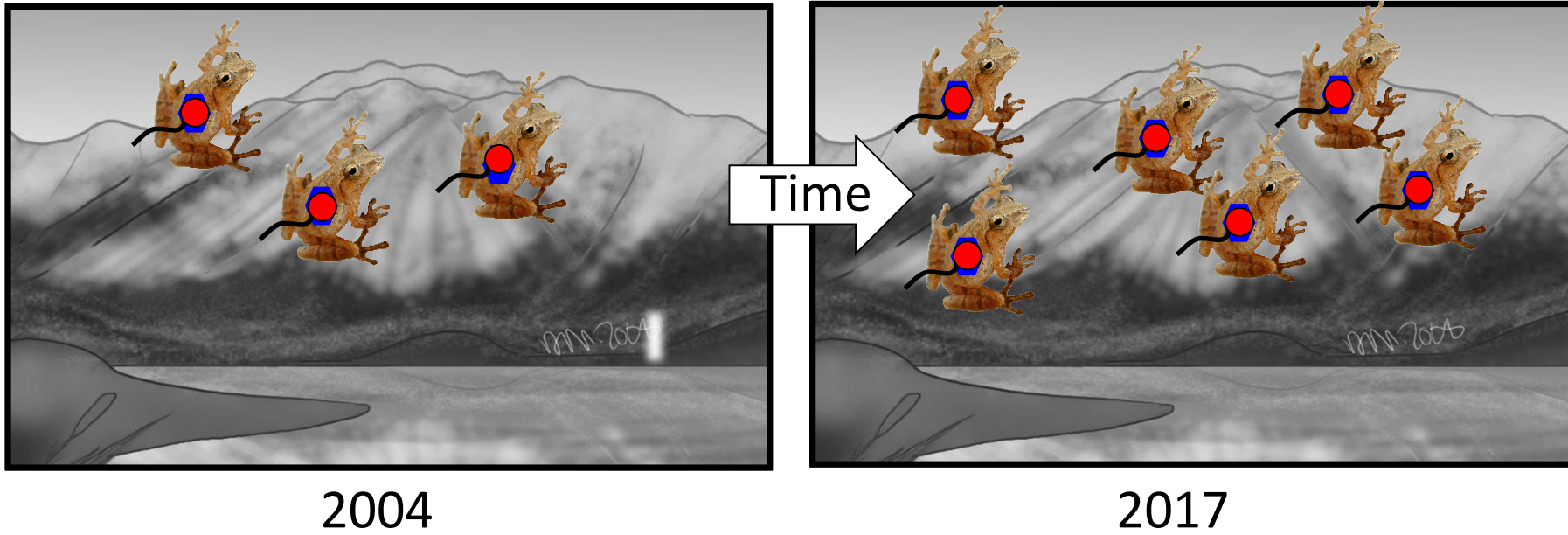


2004

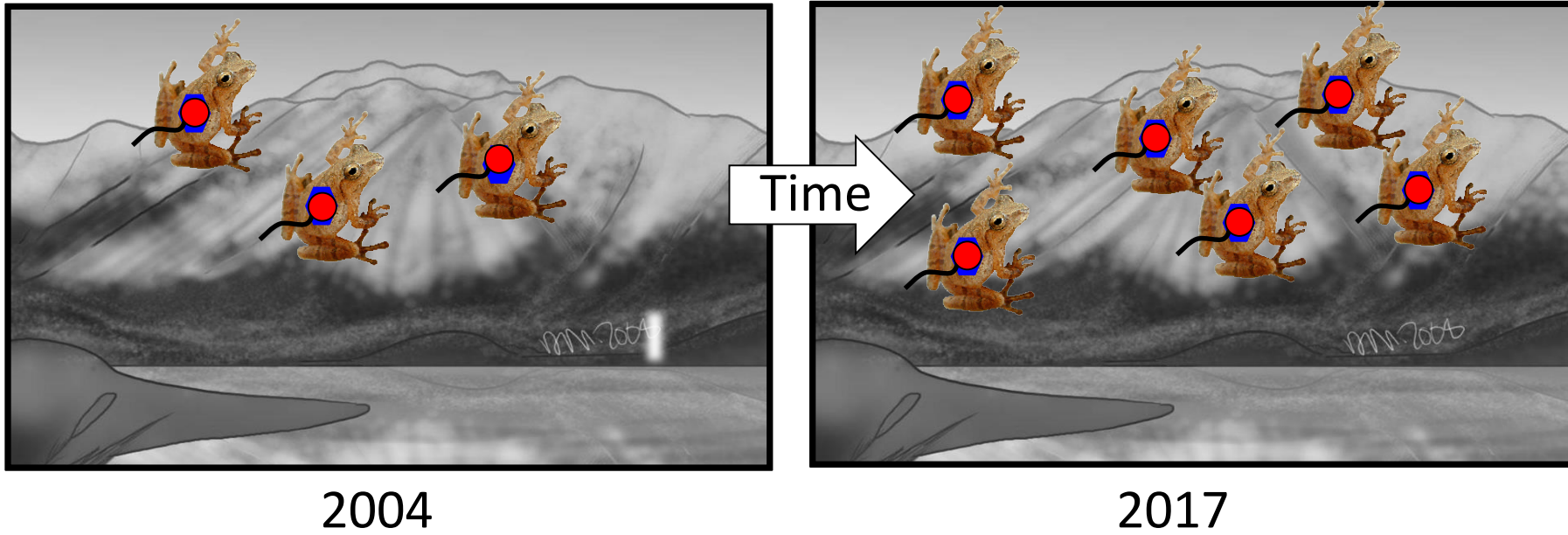


2017

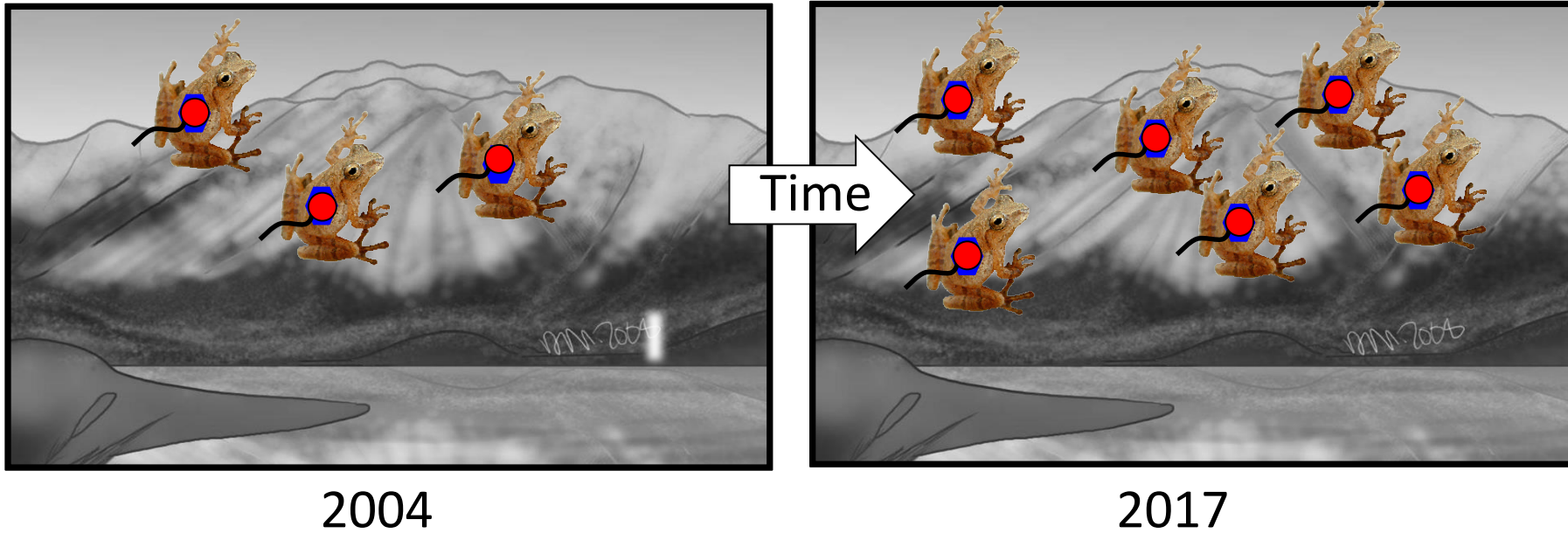




Host recovery?

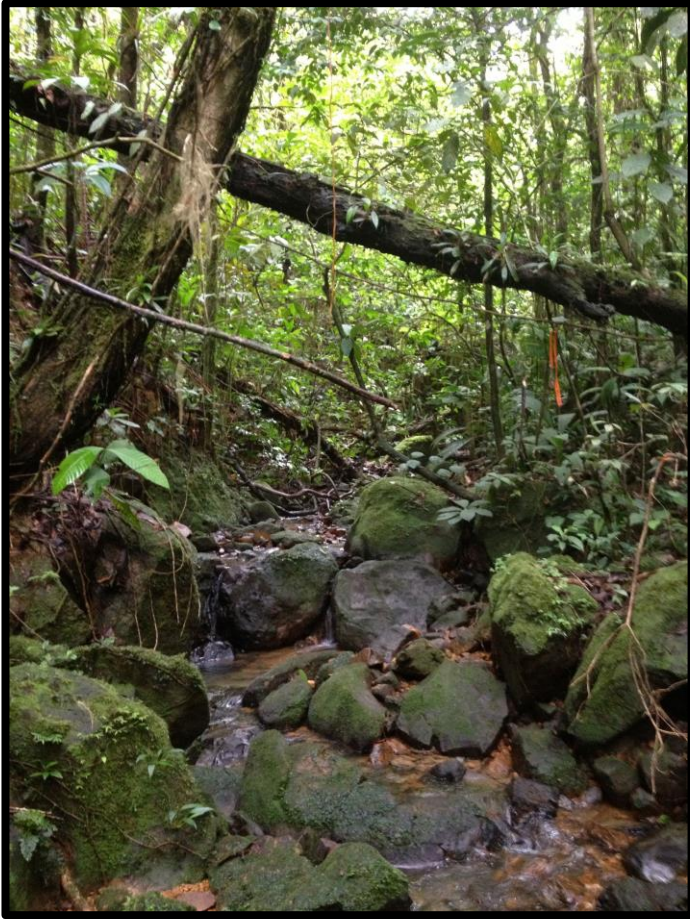


Host recovery?
Lower pathogen virulence?



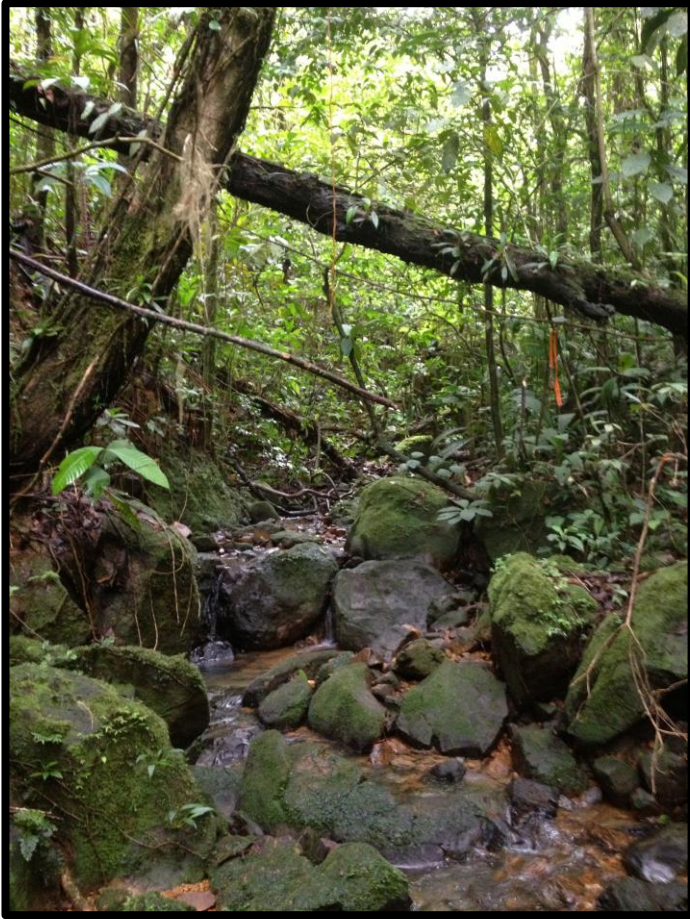
Host recovery?
Lower pathogen virulence?
Increased host resistance?

Methods



- Long-term field surveys
- Established transects

Methods



- Long-term field surveys
- Established transects

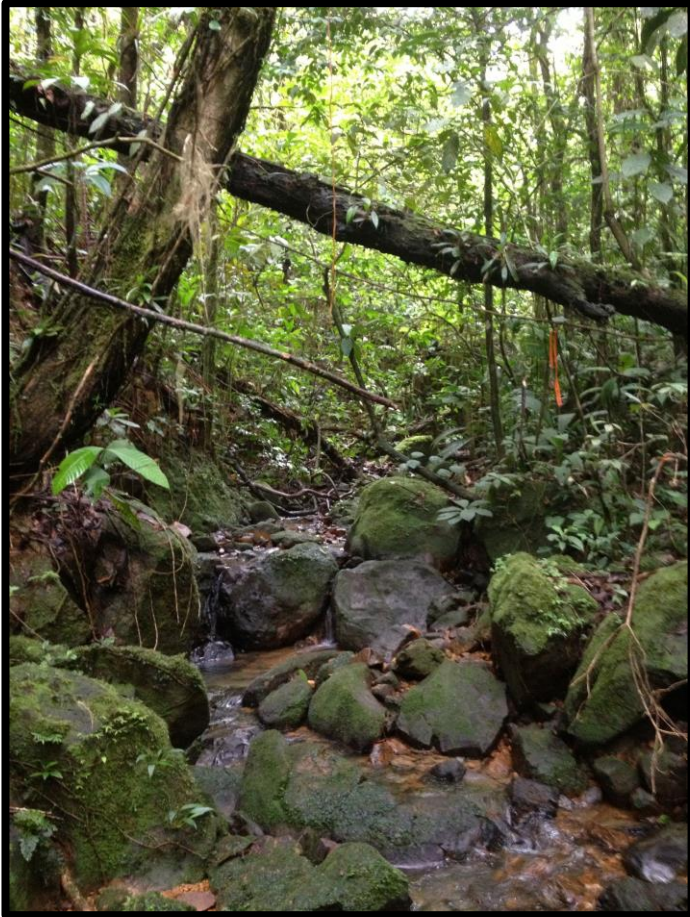


- Record a range of ecological variables



- Record species, sex, mass, SVL, body temperature, microhabitat use

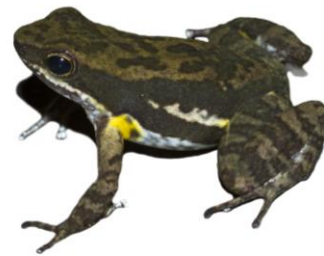
Methods



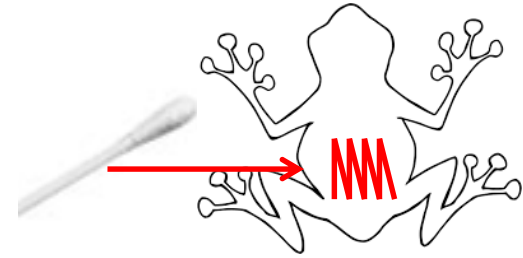
- Long-term field surveys
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- Record a range of ecological variables



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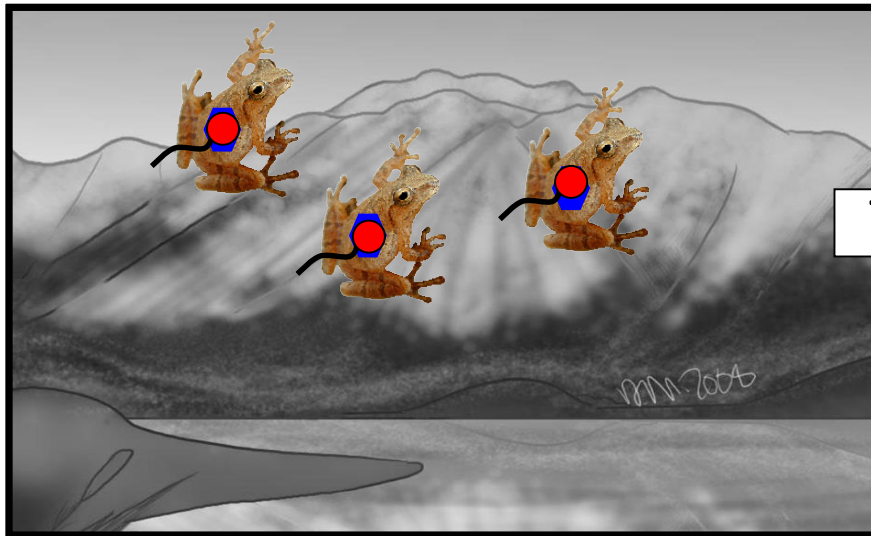
- *Bd* diagnostic sample
- Skin secretion sample

- Post-mortem, isolate *Bd*

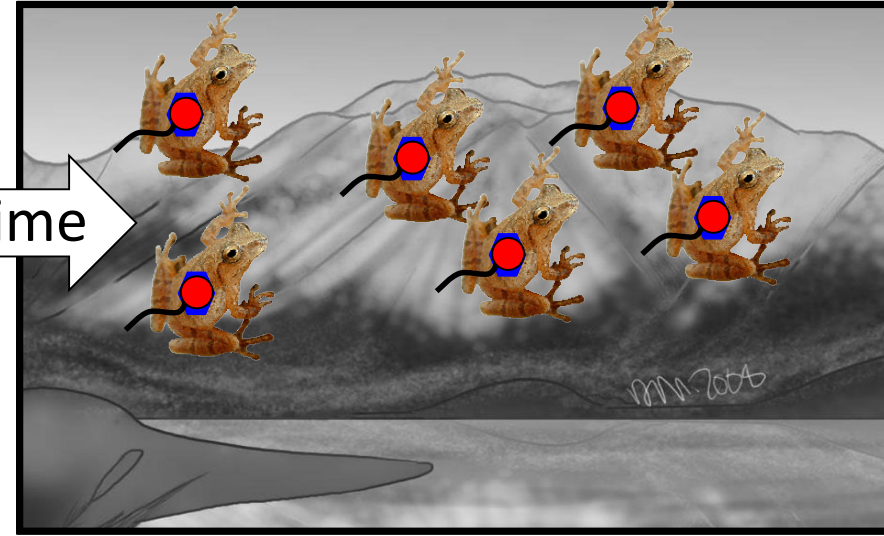


Dead metamorph

 - Highly pathogenic *Bd*



2004



2017



Infection patterns



Historic *Bd*



Historic secretions



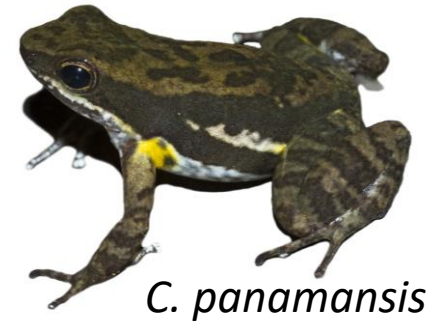
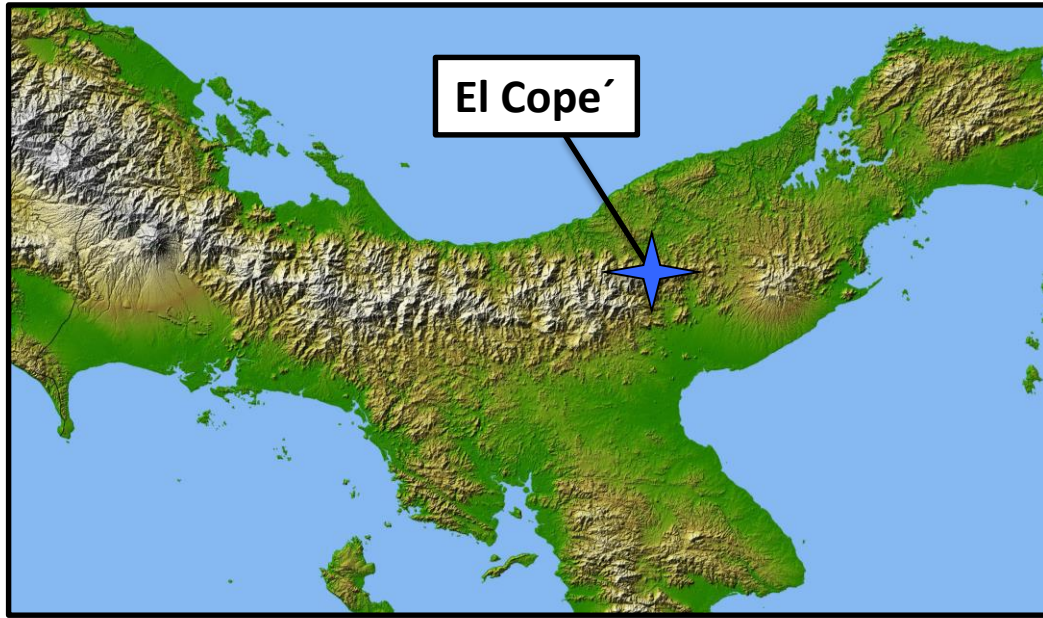
Infection patterns



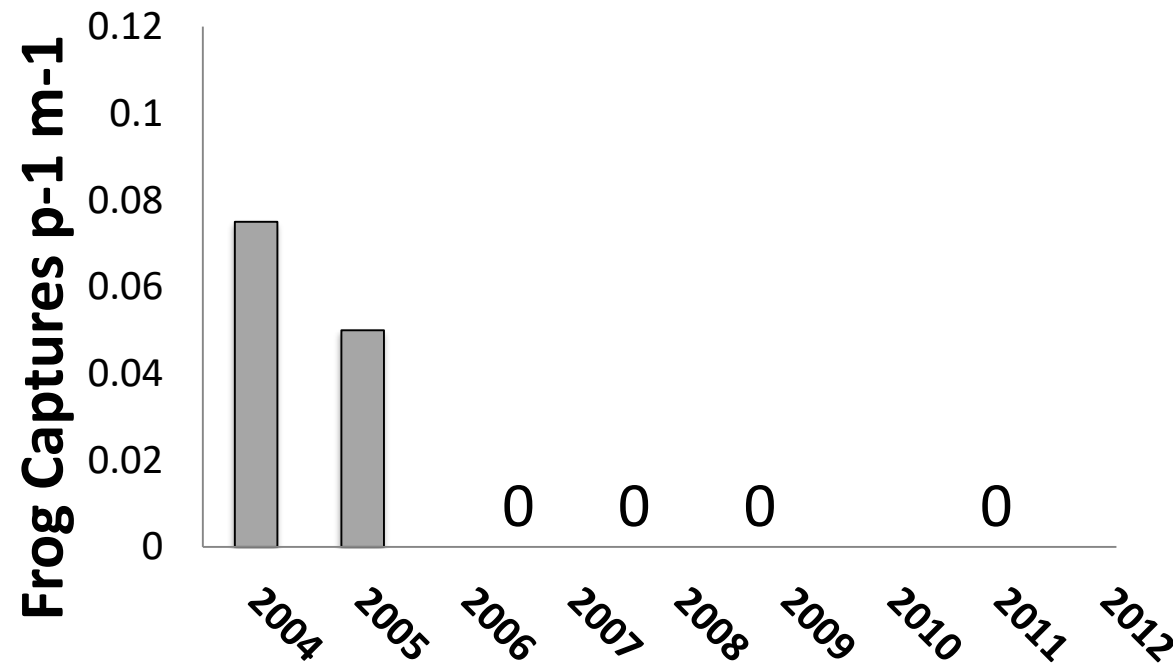
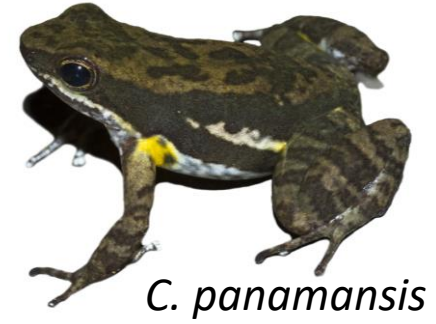
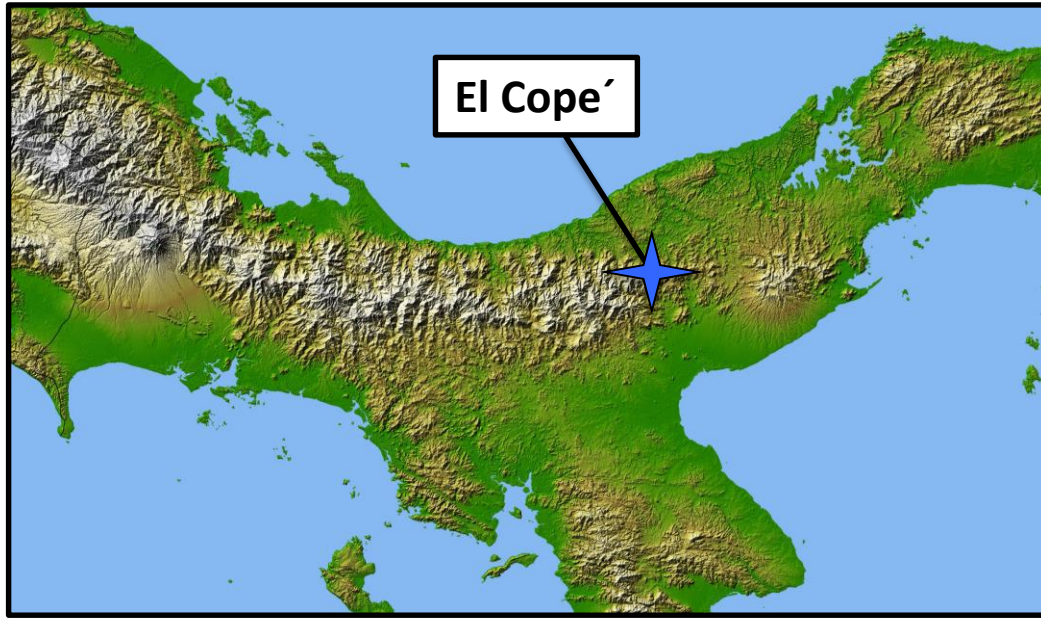
Contemporary *Bd*



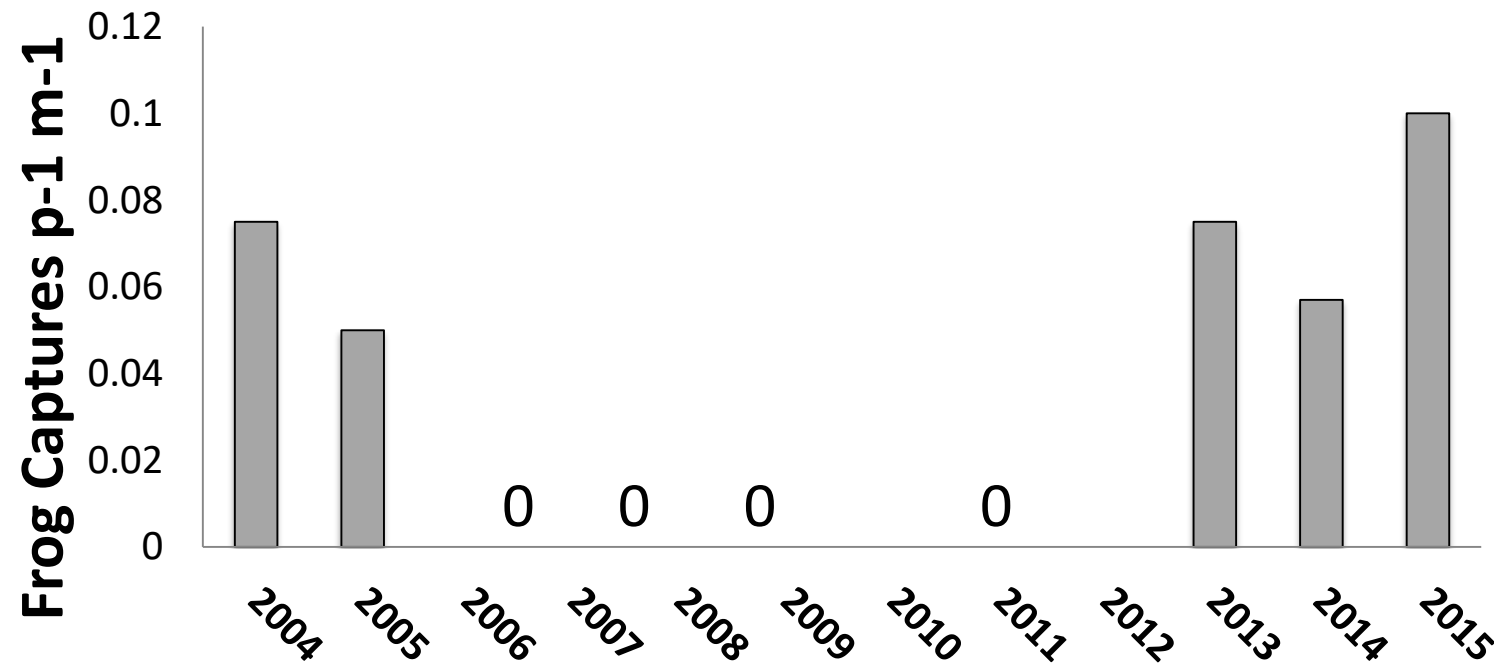
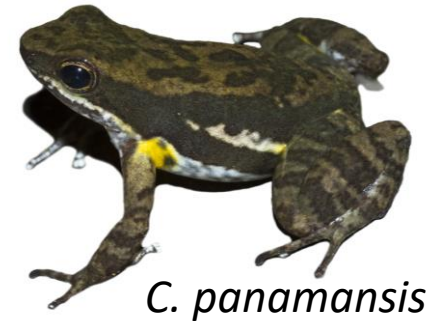
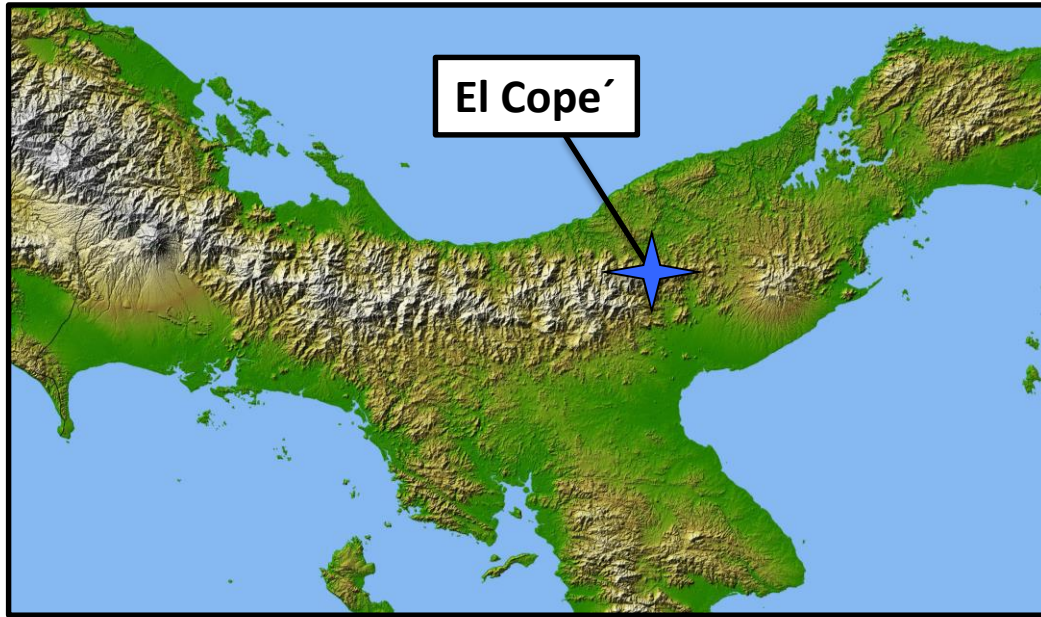
Contemporary secretions



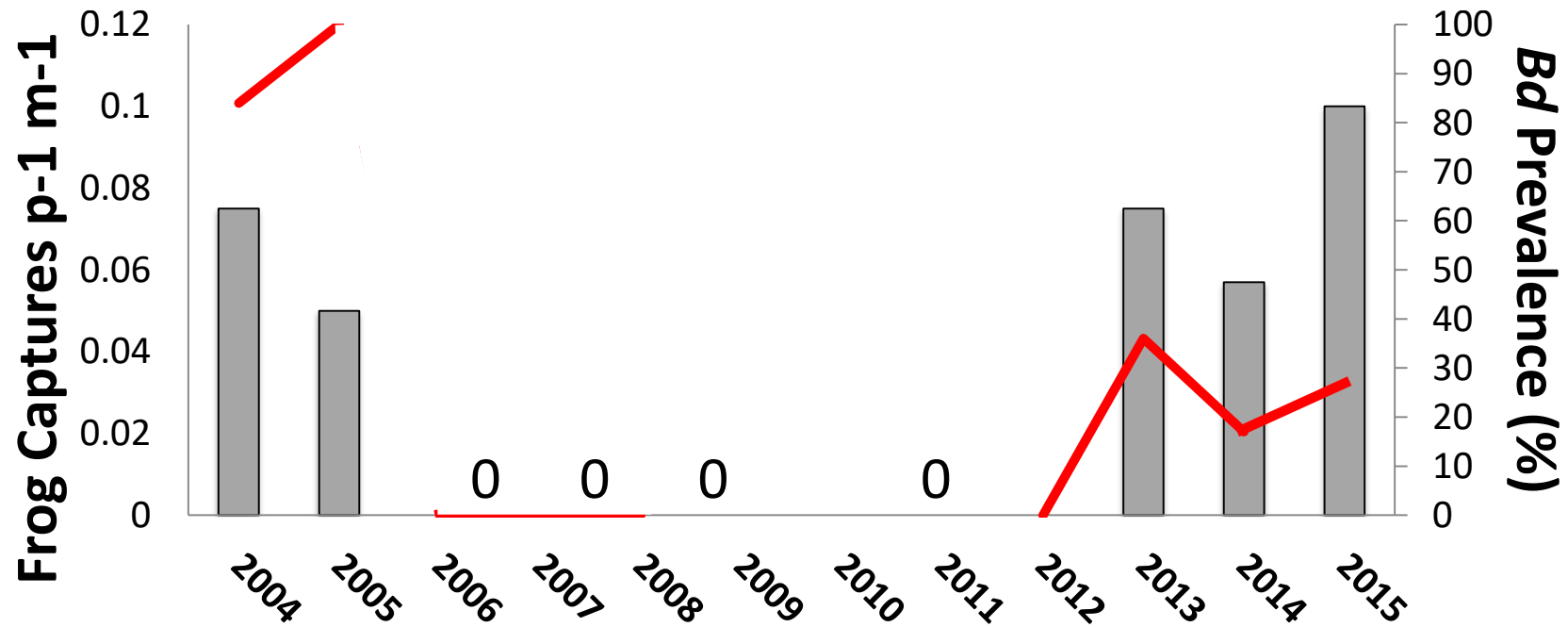
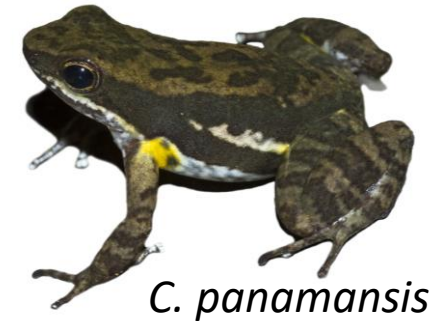
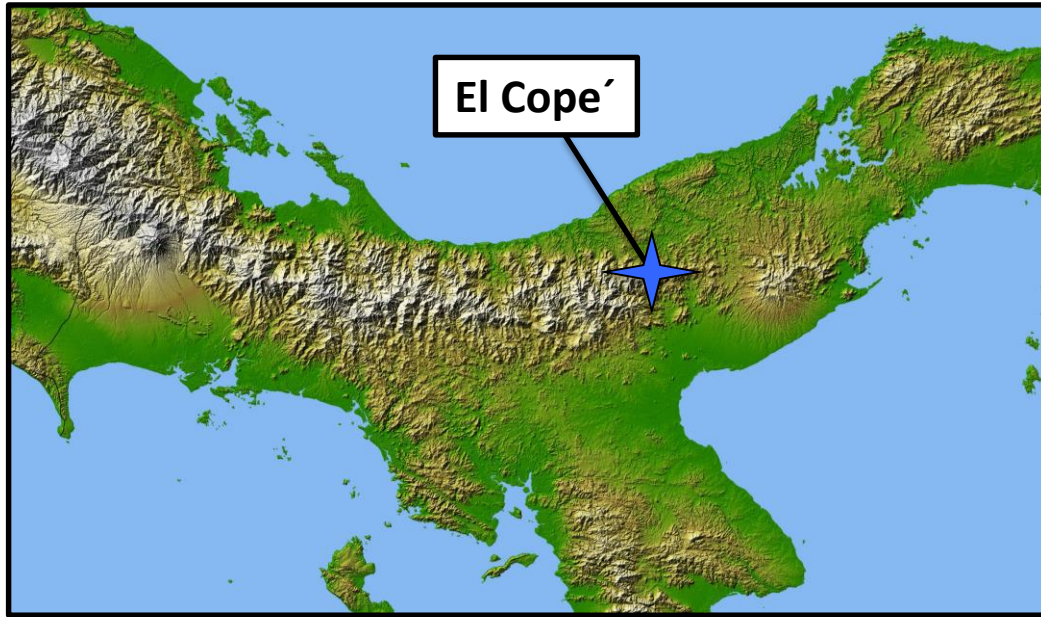
C. panamansis



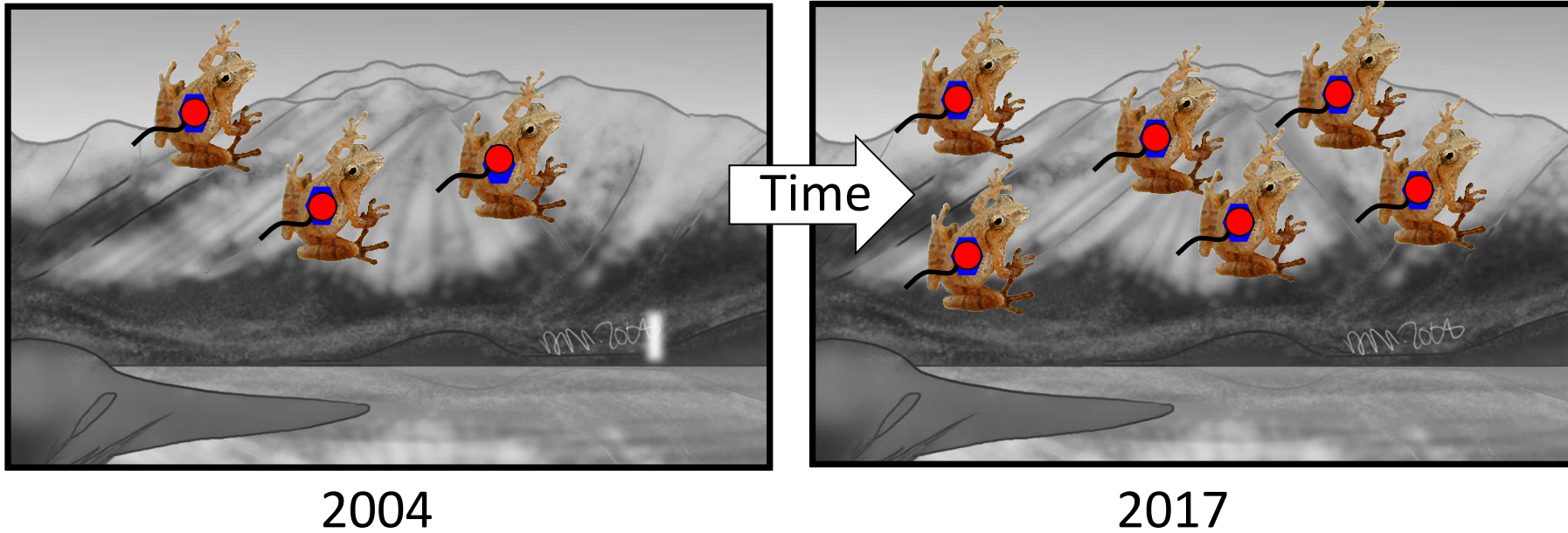
Voyles et al. 2018 *Science*



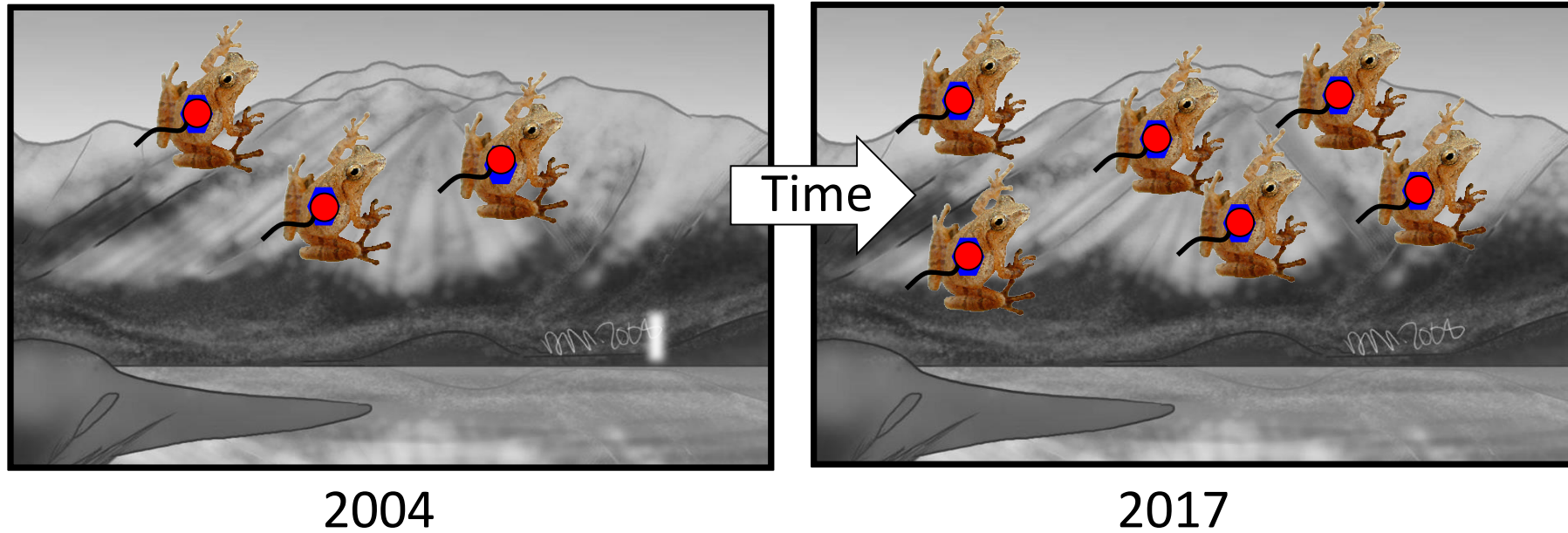
Voyles et al. 2018 *Science*



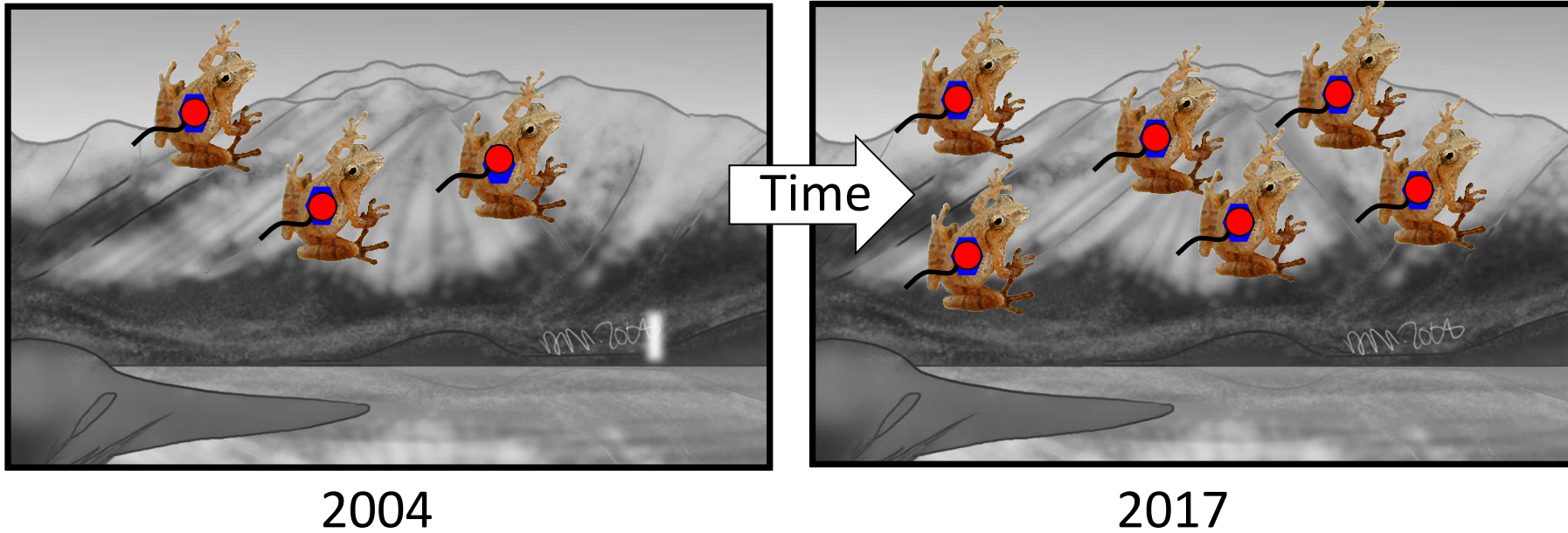
Voyles et al. 2018 *Science*



Host recovery
Lower pathogen virulence?
Increased host resistance?



- ✓ **Host recovery**
 - Lower pathogen virulence?
 - Increased host resistance?



- ✓ **Host recovery, low *Bd* prevalence**
Lower pathogen virulence?
Increased host resistance?



Infection patterns



Historic *Bd*



Historic secretions

2004



Infection patterns

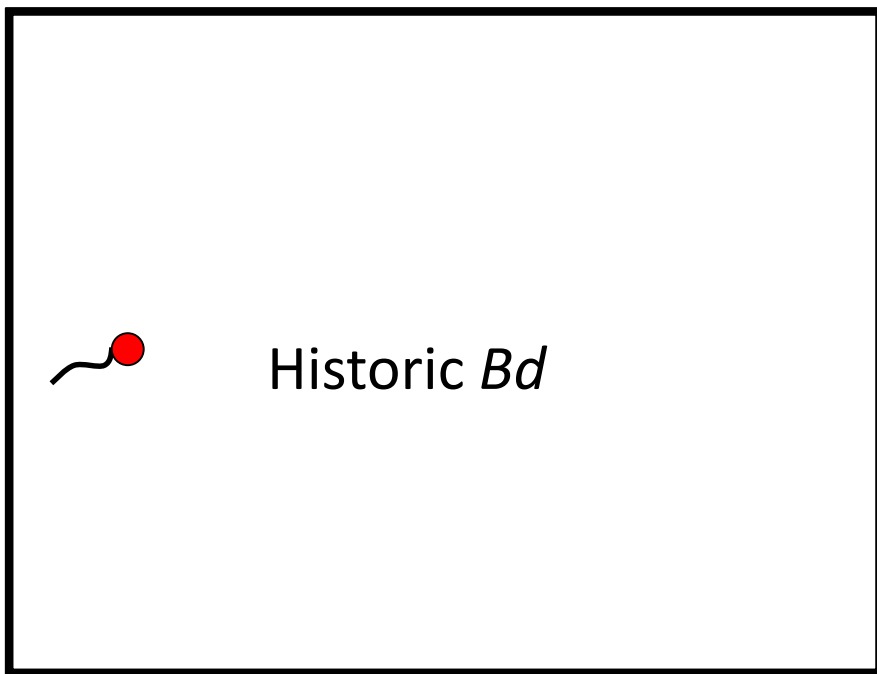


Contemporary *Bd*

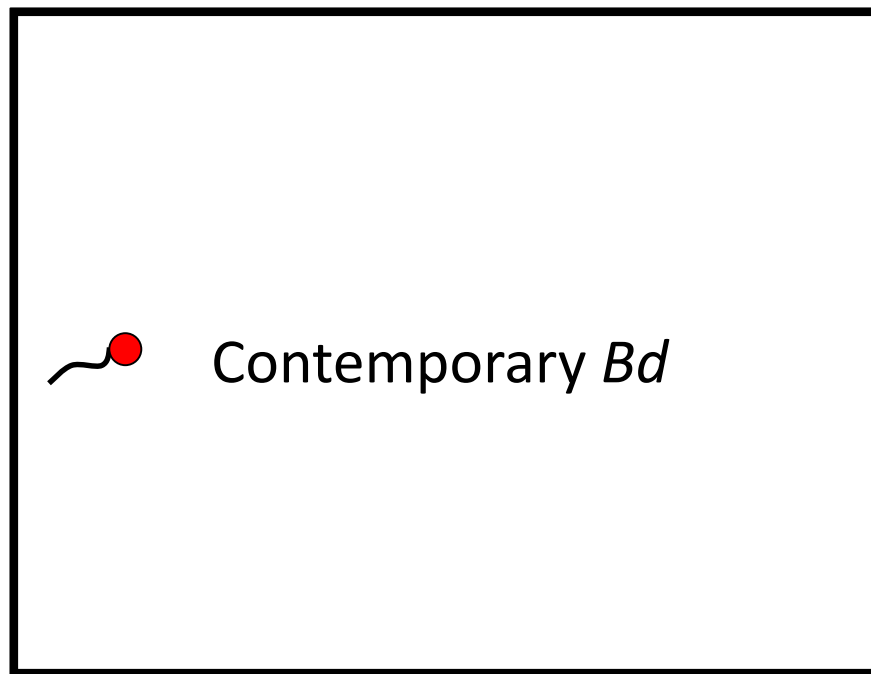


Contemporary secretions

2017



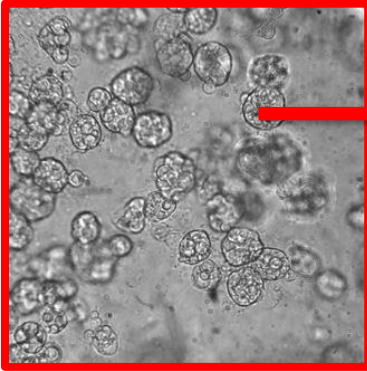
2004



2017

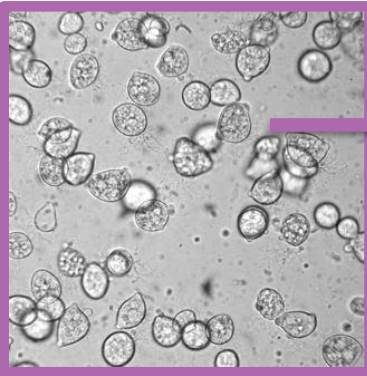
Are Contemporary *Bd* isolates less pathogenic?

3 Historic *Bd* Isolates



N = 10 frogs
per group

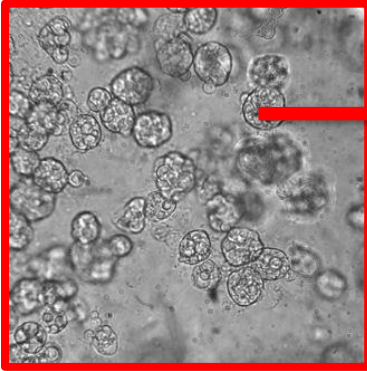
3 Contemporary *Bd* Isolates



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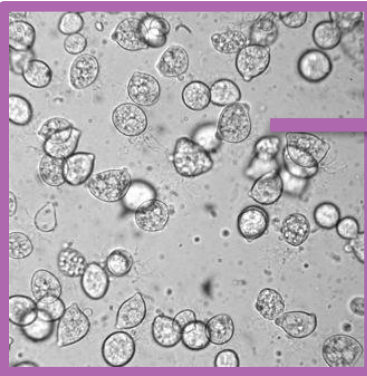
Are Contemporary *Bd* isolates less pathogenic?

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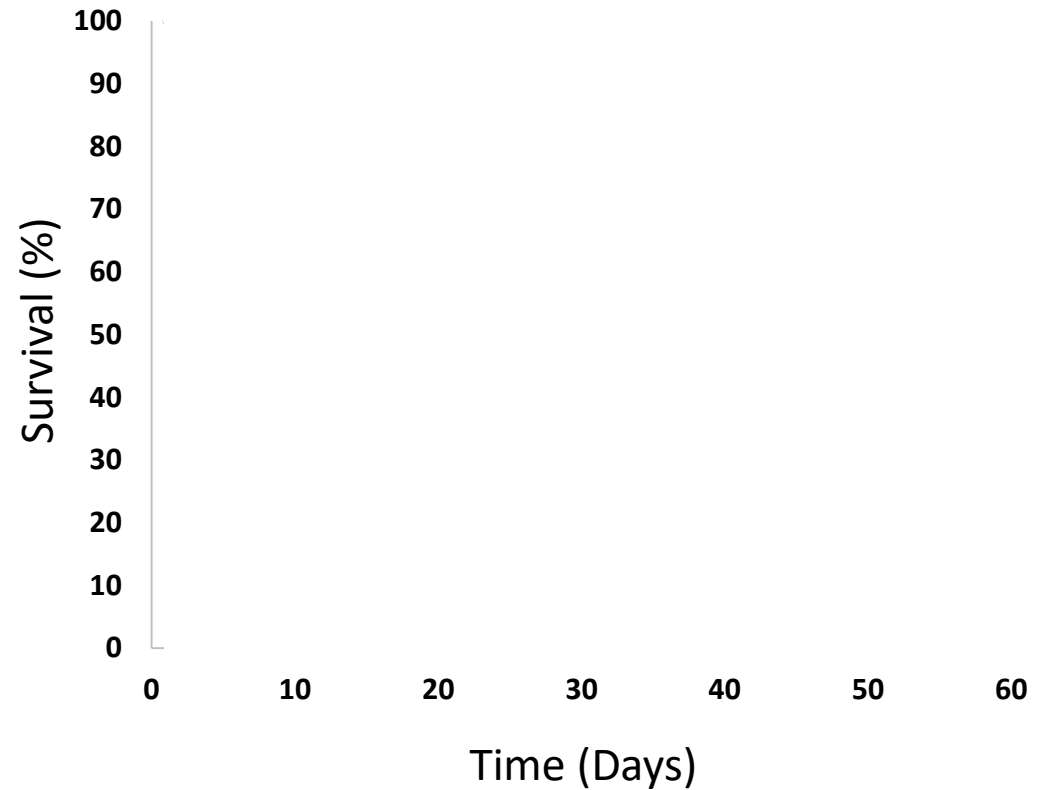


N = 10 frogs
per group

3 Contemporary *Bd* Isolates

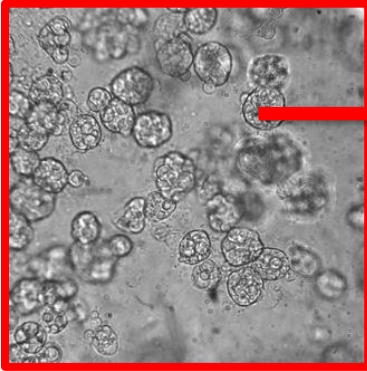


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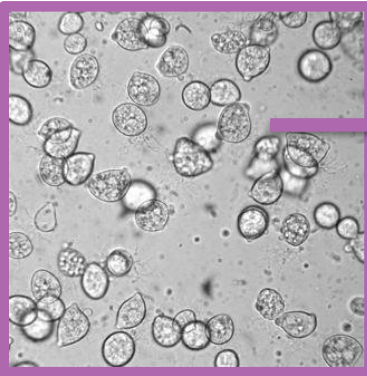
Are Contemporary *Bd* isolates less pathogenic?

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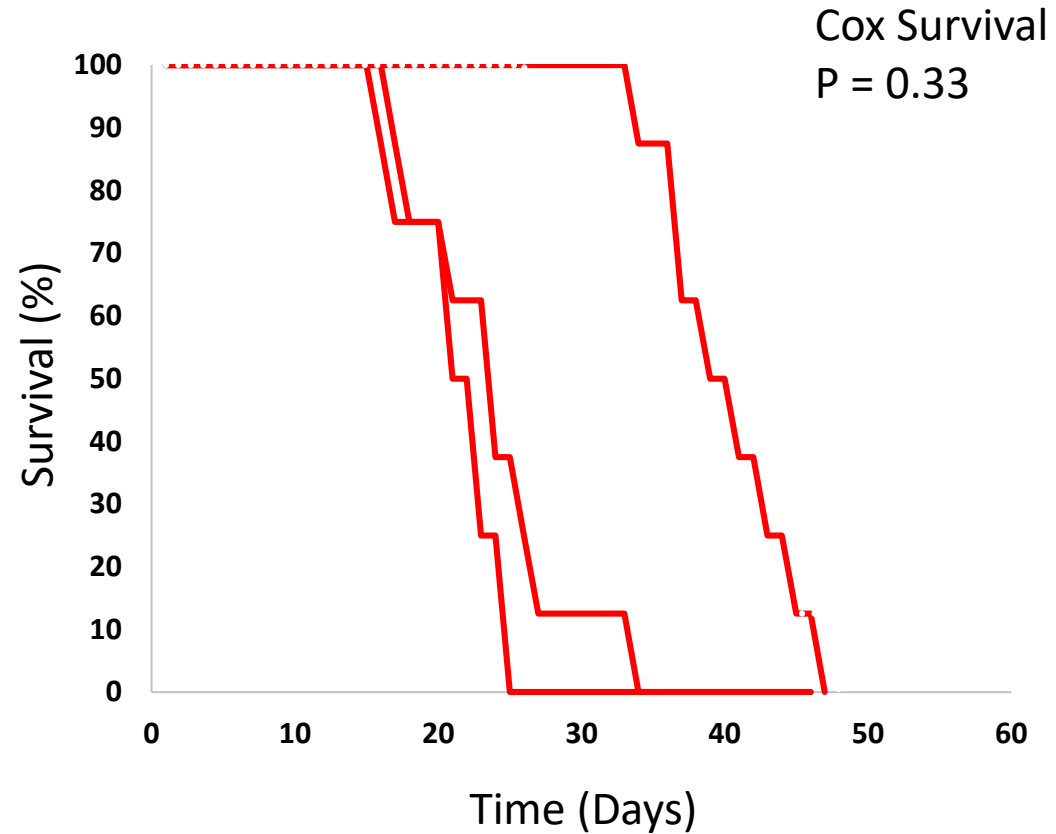


N = 10 frogs
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3 Contemporary *Bd* Isolates

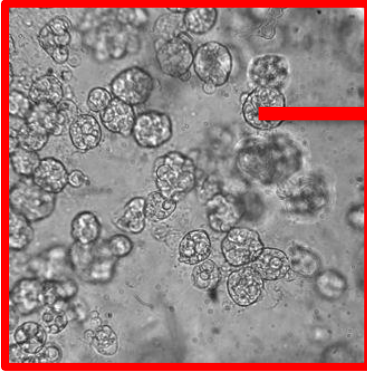


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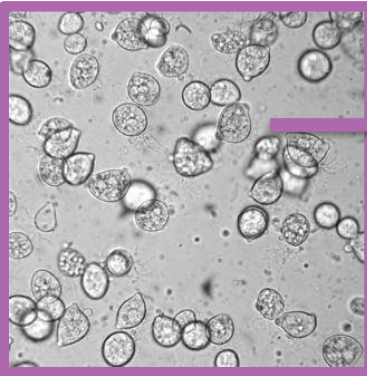
Are Contemporary *Bd* isolates less pathogenic?

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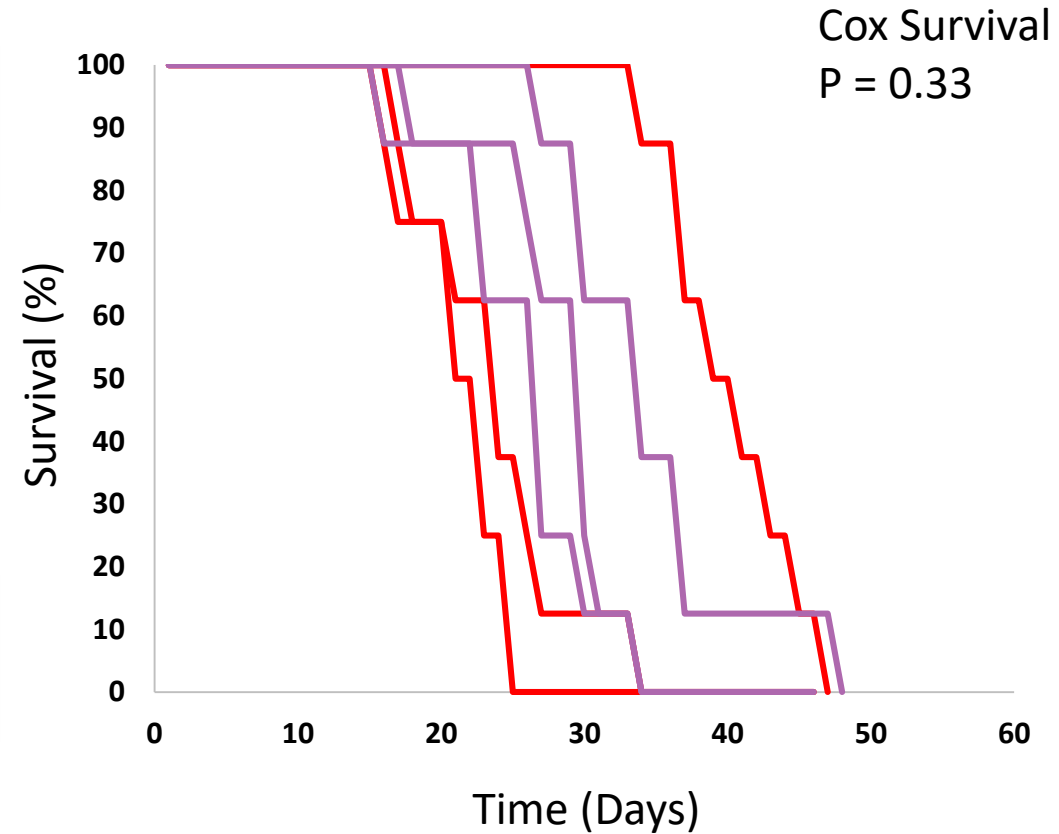


N = 10 frogs
per group

3 Contemporary *Bd* Isolates

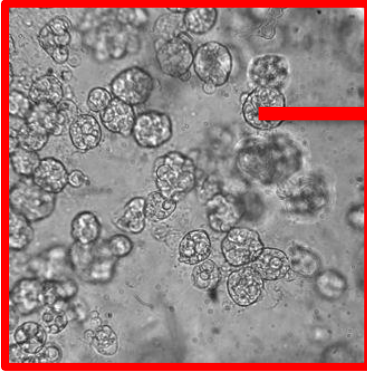


N = 10 frogs
per group



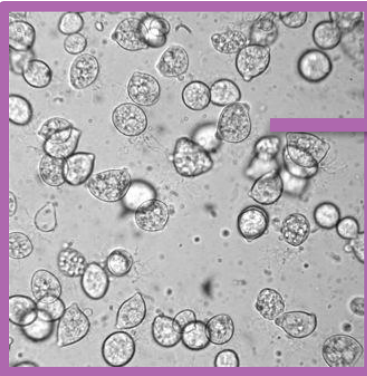
Are Contemporary *Bd* isolates less pathogenic?

3 Historic *Bd* Isolates

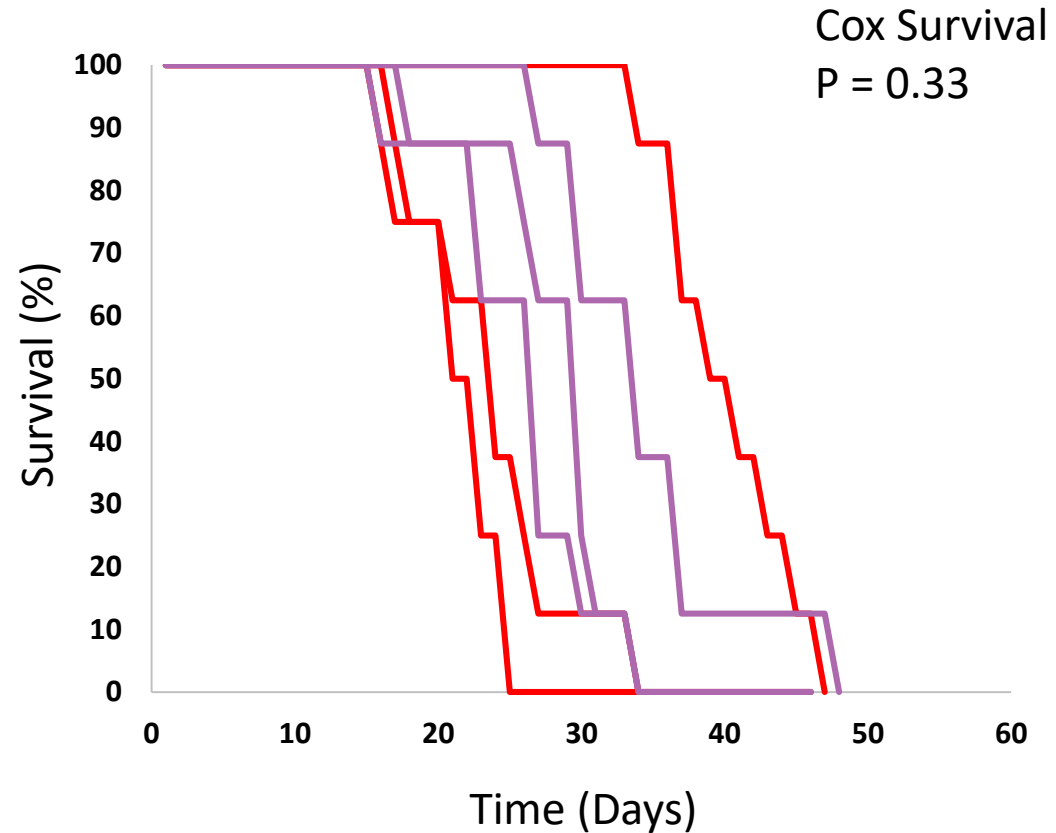


N = 10 frogs
per group

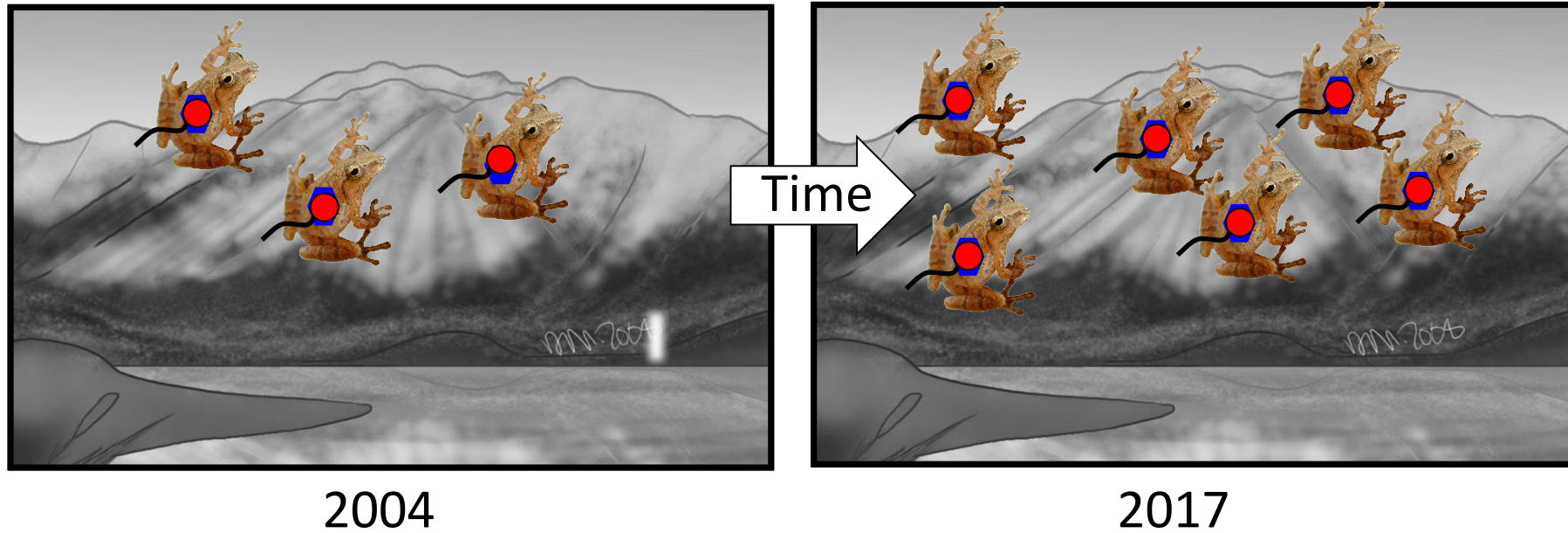
3 Contemporary *Bd* Isolates



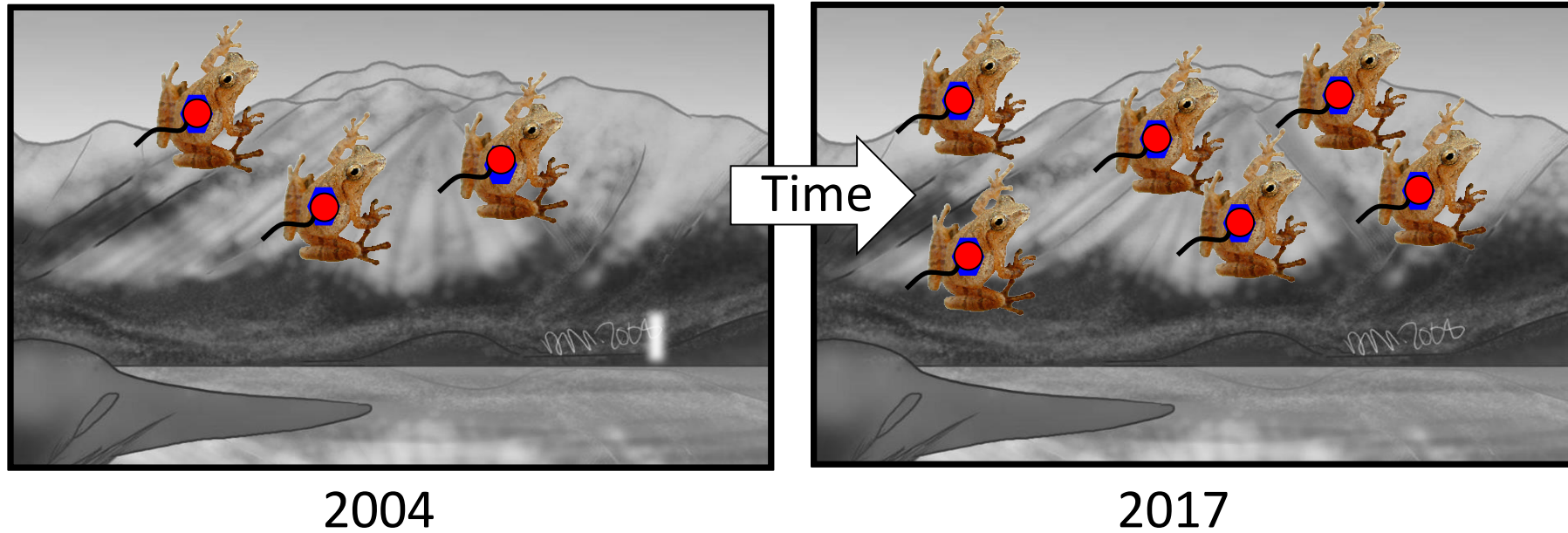
N = 10 frogs
per group



No differences between Historic and Contemporary *Bd*



- ✓ **Host recovery, low *Bd* prevalence**
Lower pathogen virulence?
Increased host resistance?



- ✓ Host recovery, low *Bd* prevalence
- ✗ Lower pathogen virulence
- Increased host resistance?



Infection patterns



Historic *Bd*



Historic secretions

2004



Infection patterns



Contemporary *Bd*



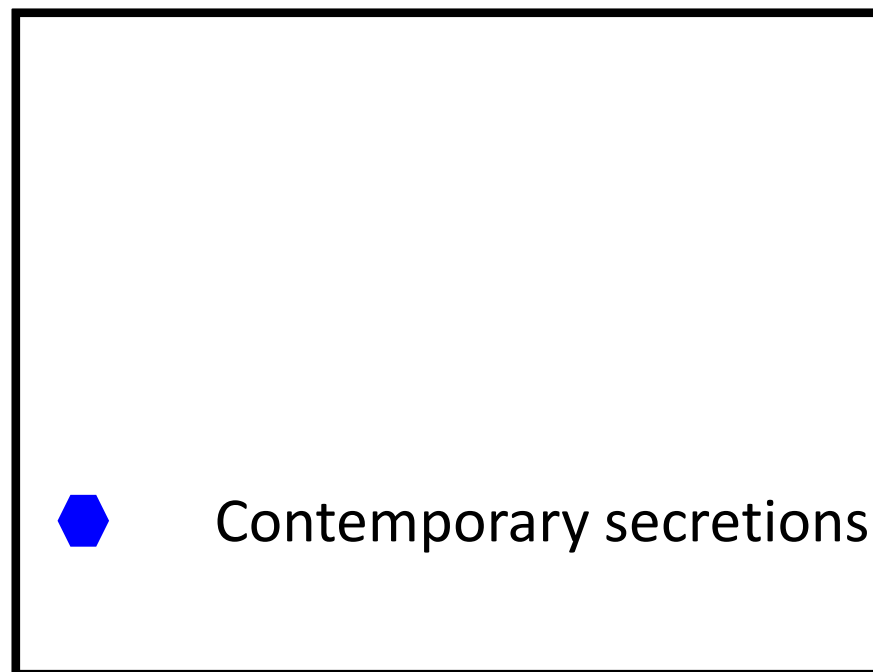
Contemporary secretions

2017



Historic secretions

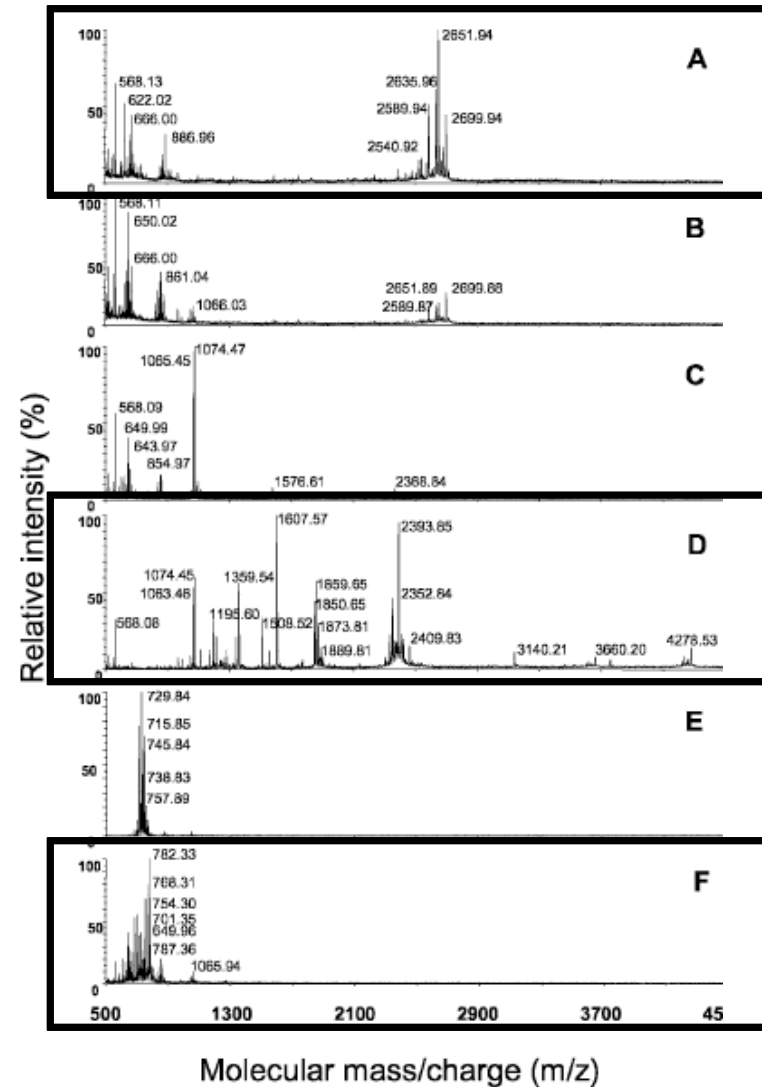
2004



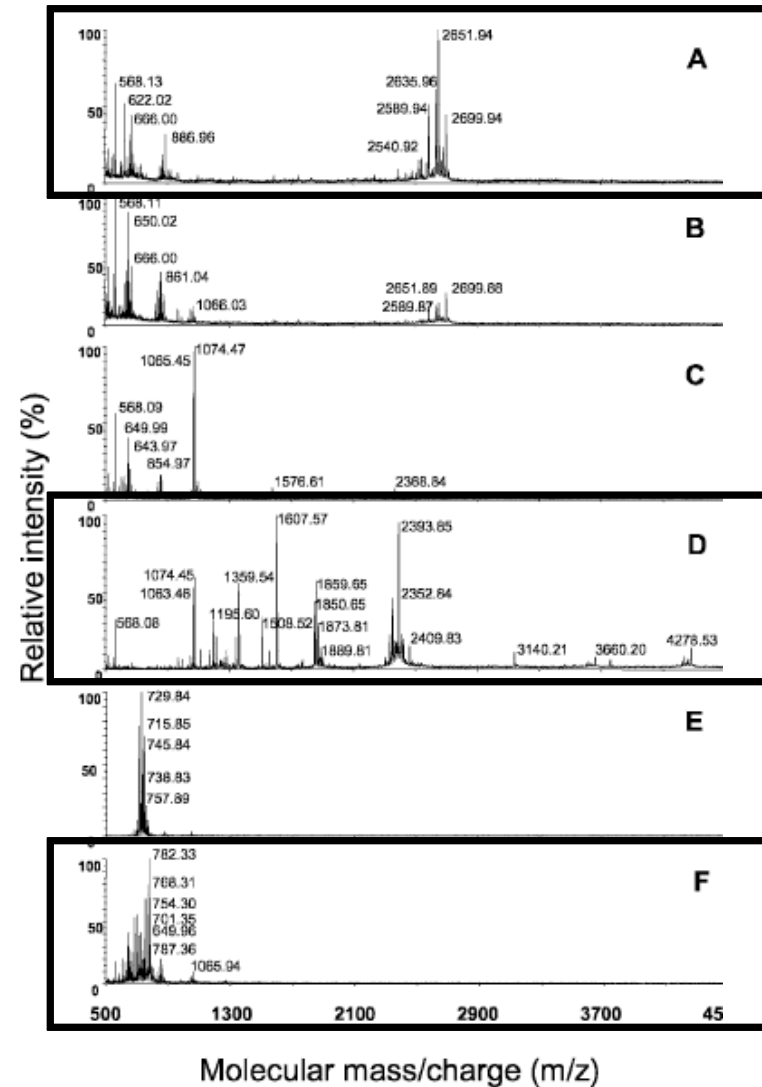
Contemporary secretions

2017

Frog defenses: Antimicrobial Peptides (AMPs)



Frog defenses: Antimicrobial Peptides (AMPs)



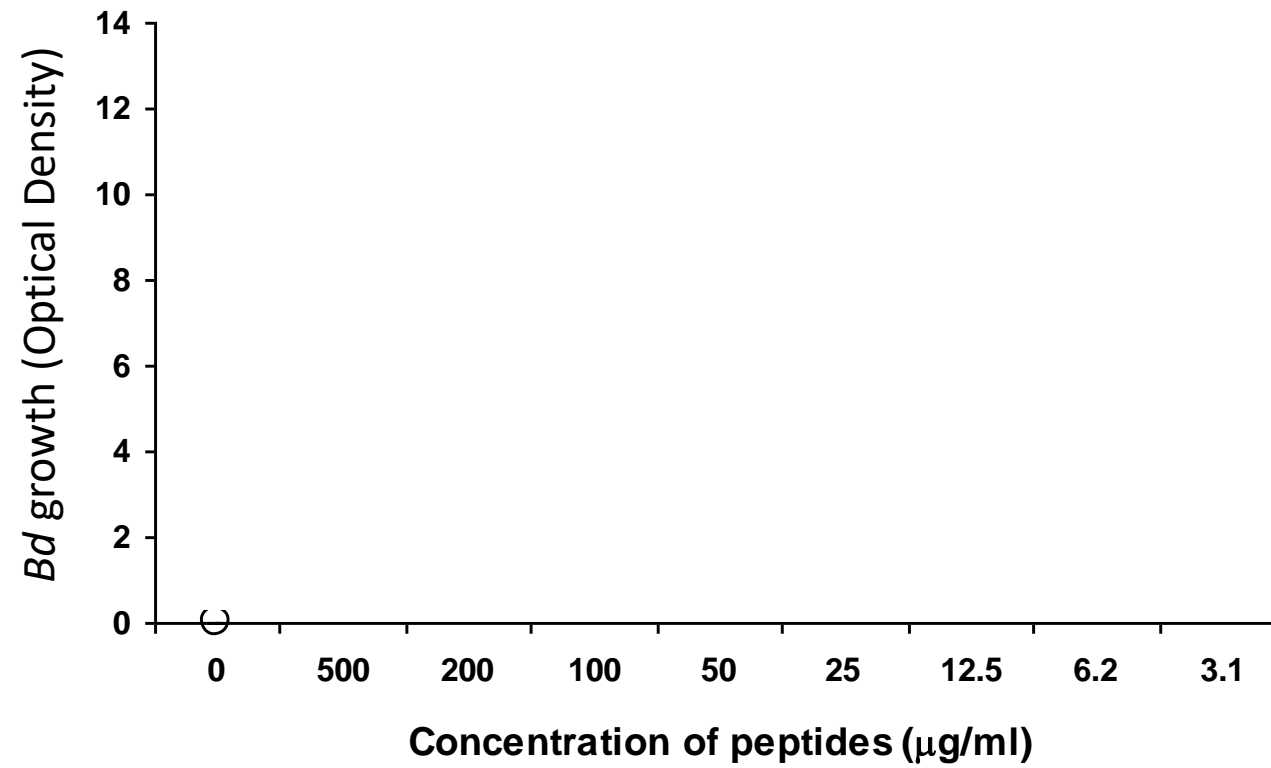
Challenge
assay

Test for
inhibition
of *Bd* growth

Peptide
effectiveness

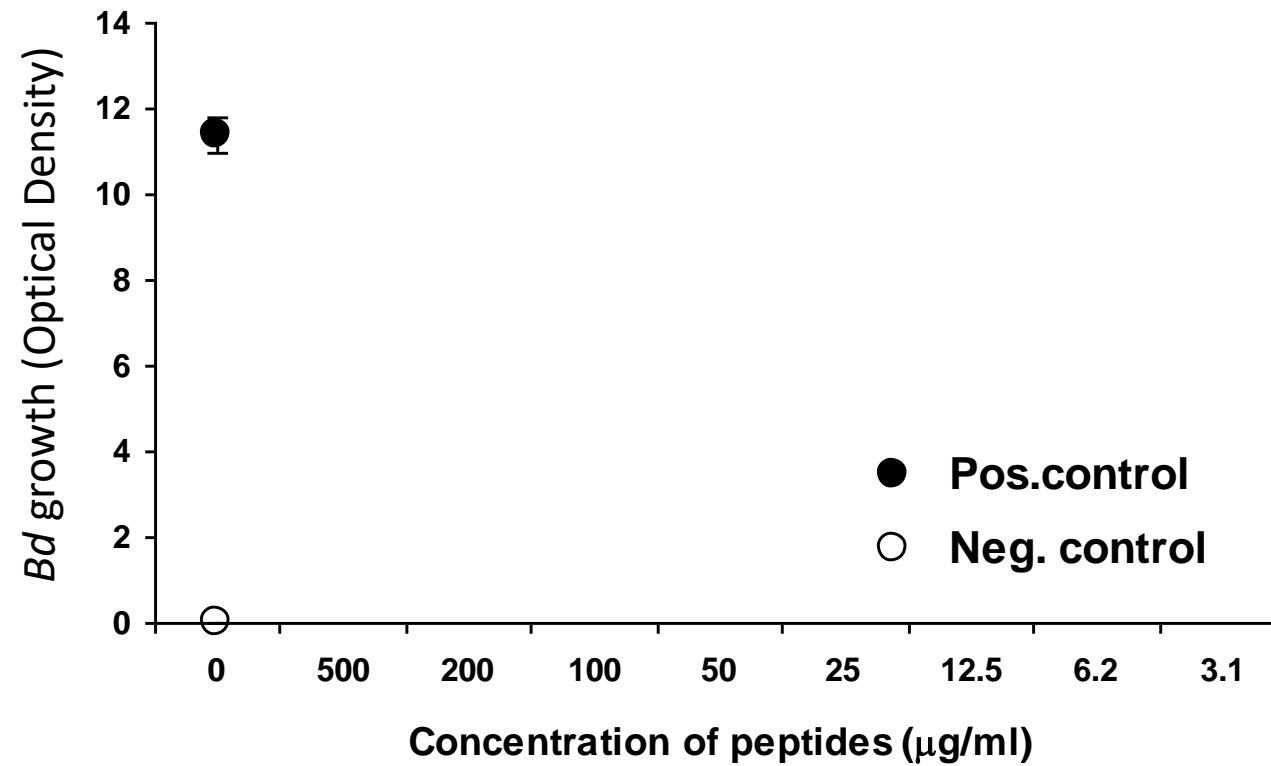


C. prosoblepon



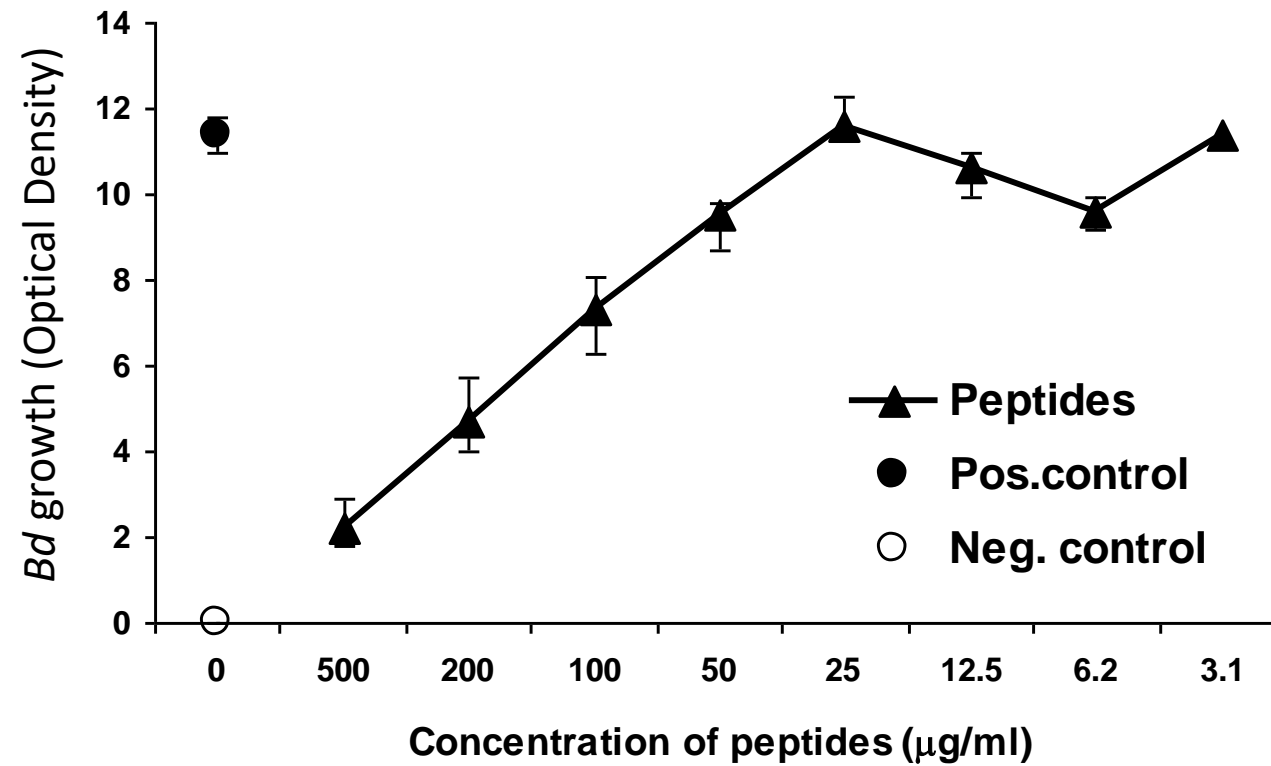


C. prosoblepon

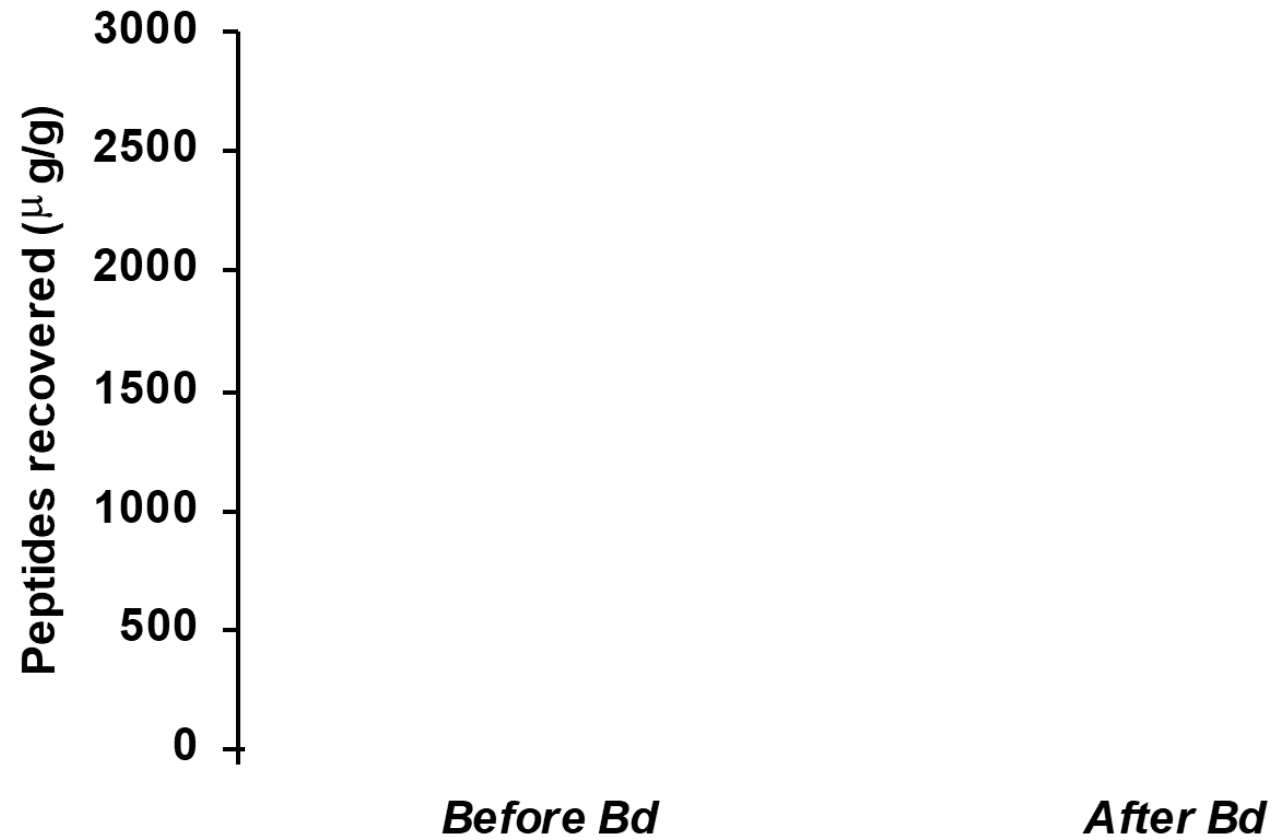




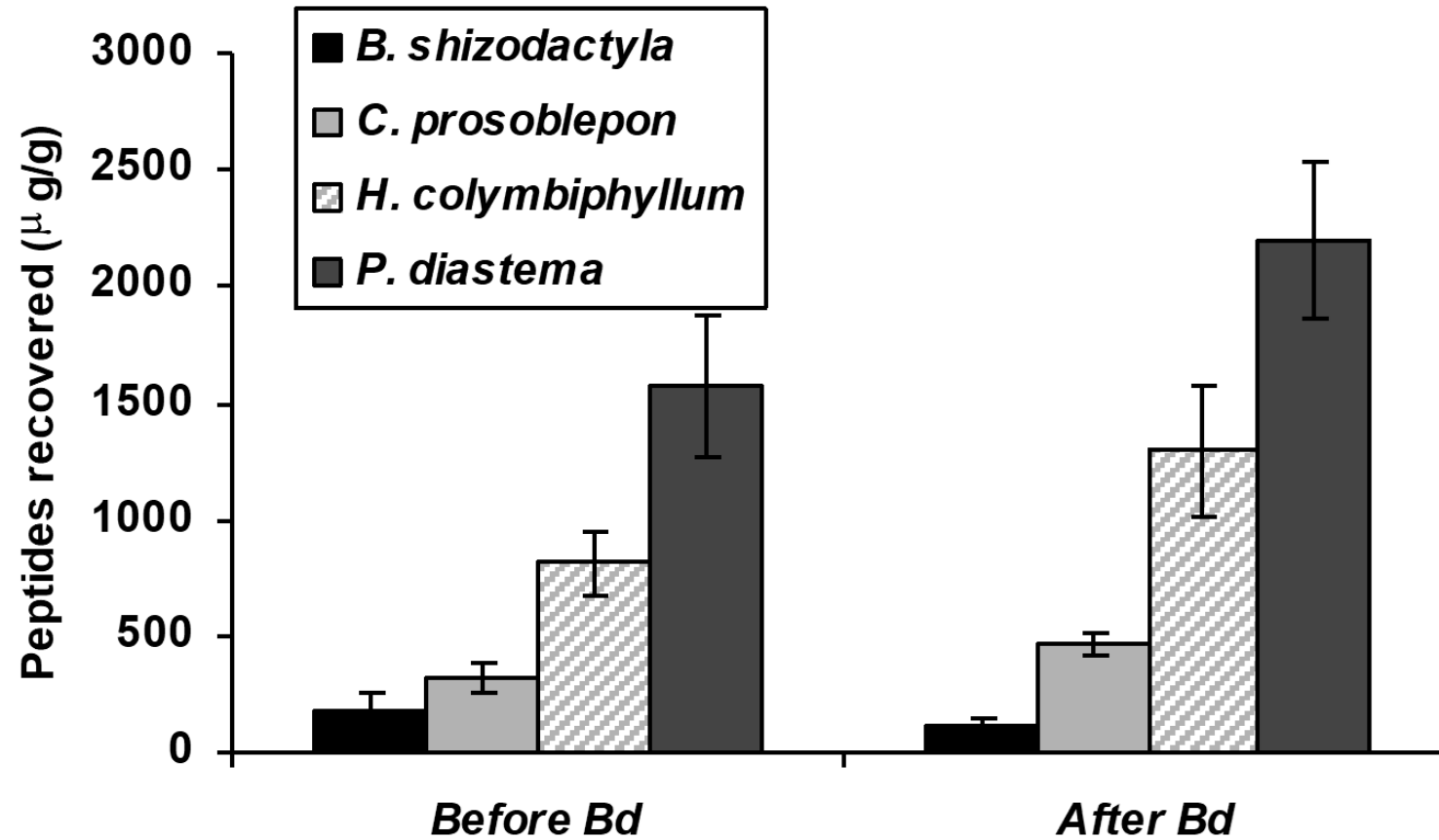
C. prosoblepon



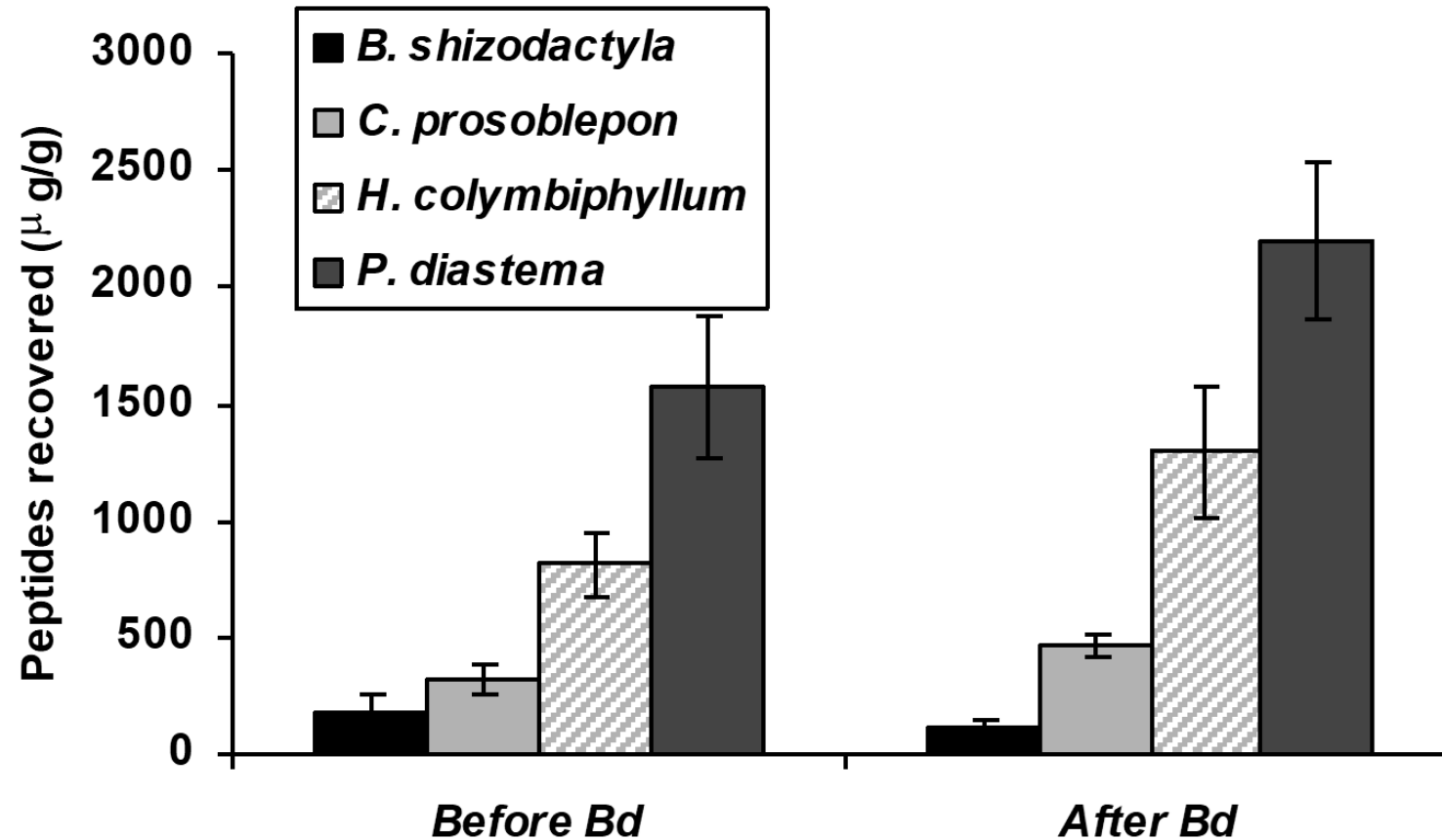
Changes in the amount of AMPs produced?



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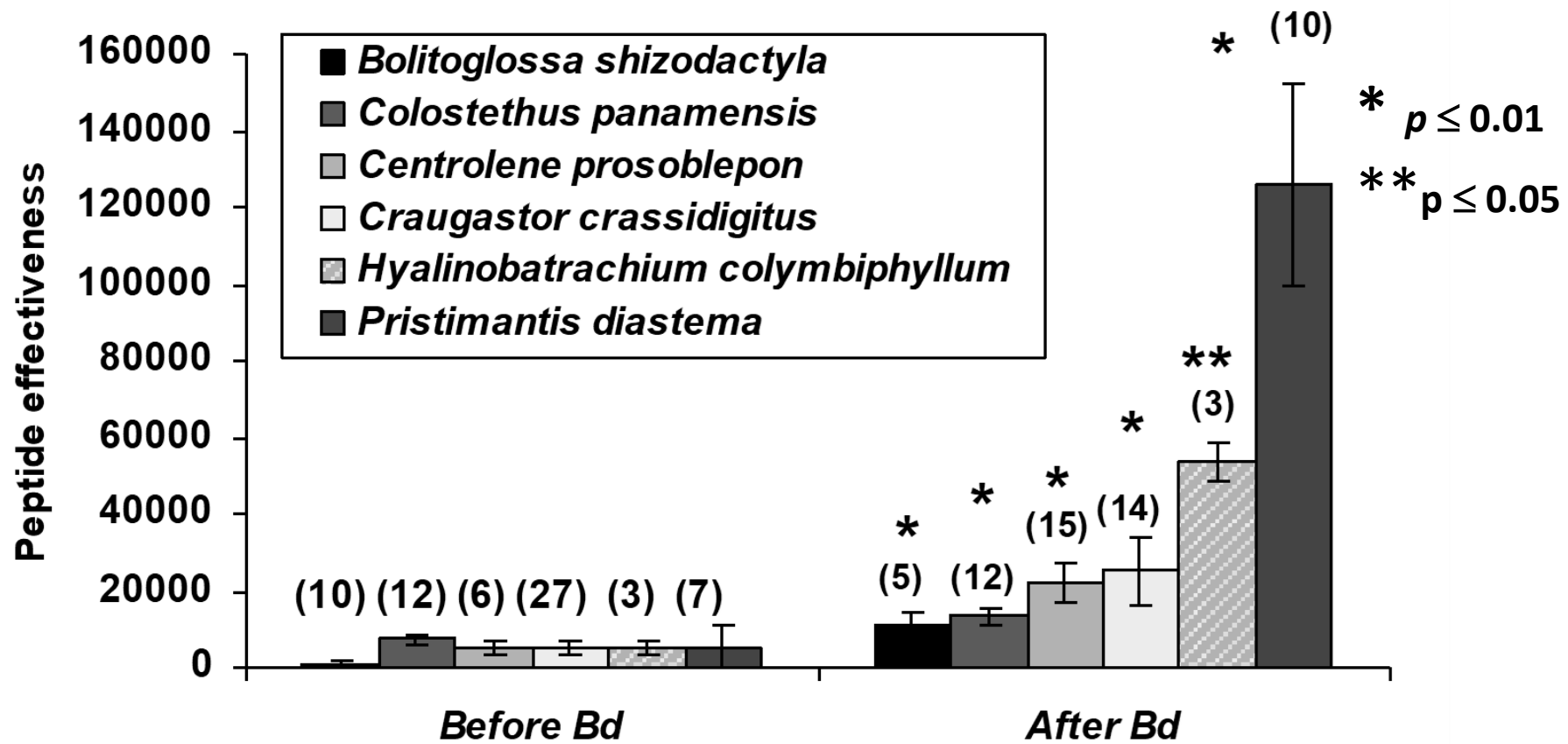


No differences in the amount of AMPs produced

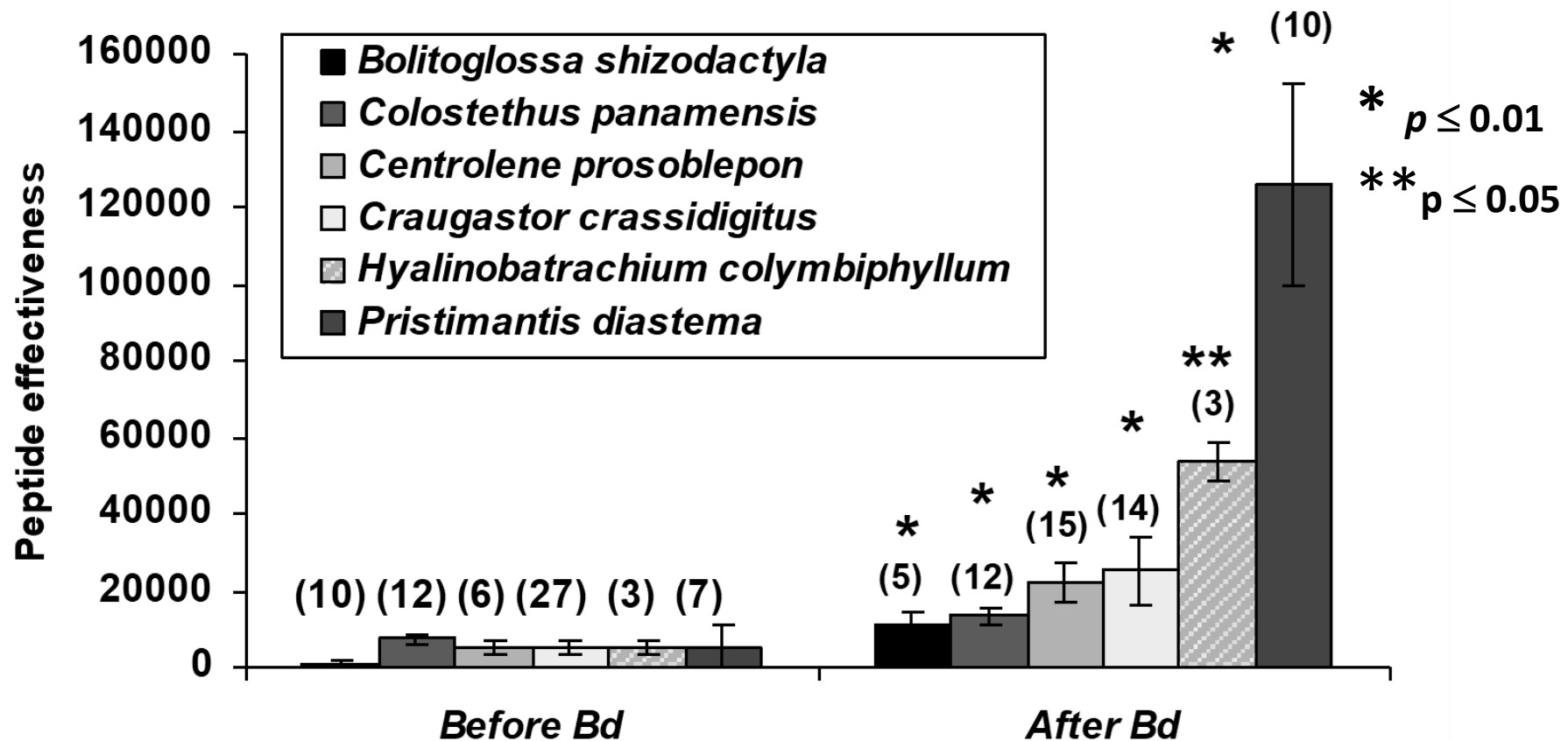
Changes in AMP effectiveness against Bd?



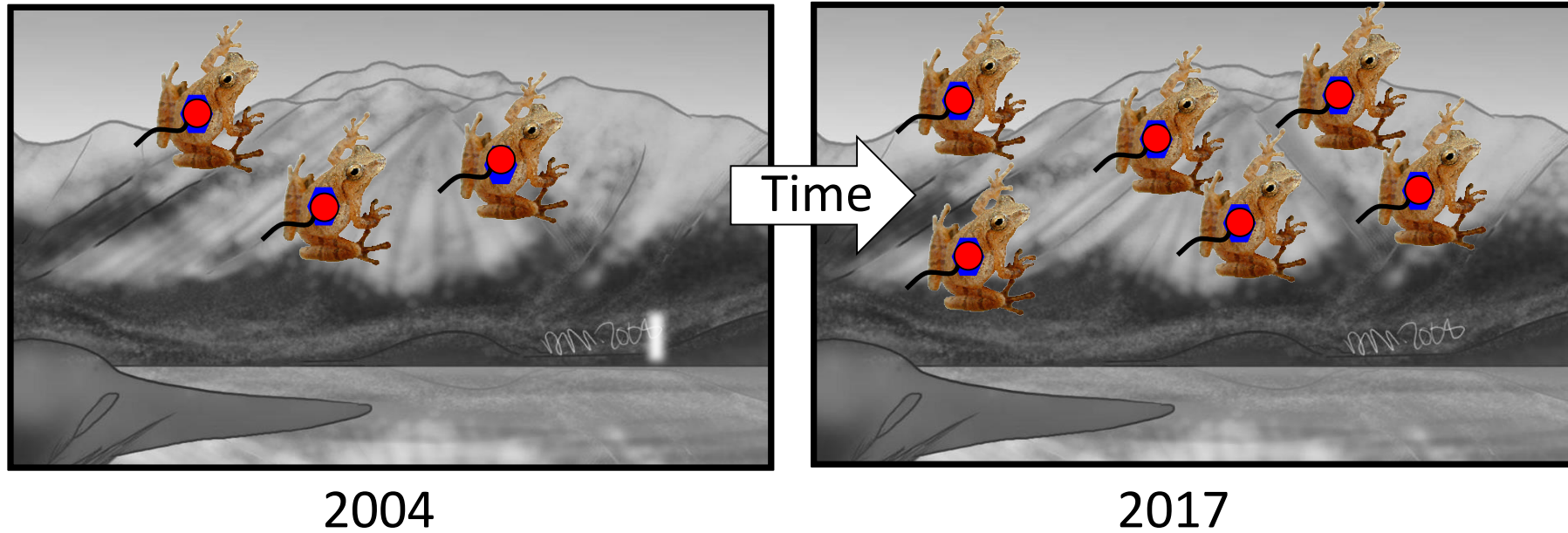
Changes in AMP effectiveness against Bd?



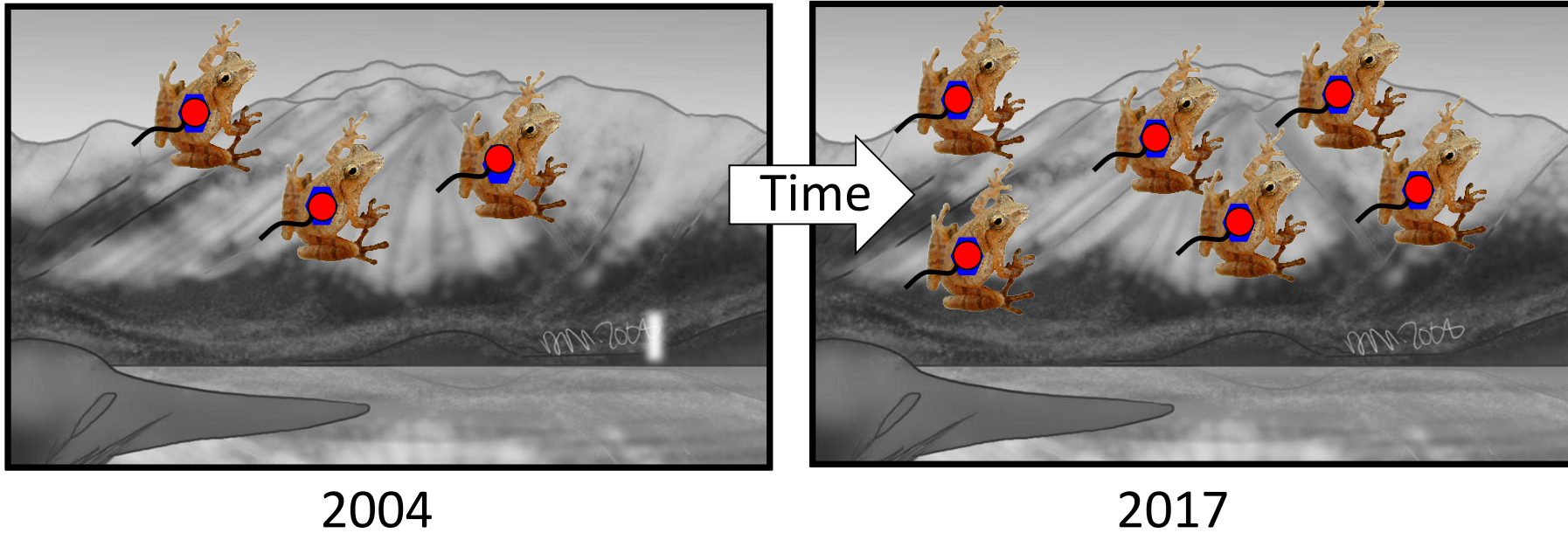
Changes in AMP effectiveness against Bd?



Significant differences AMP effectiveness against *Bd*



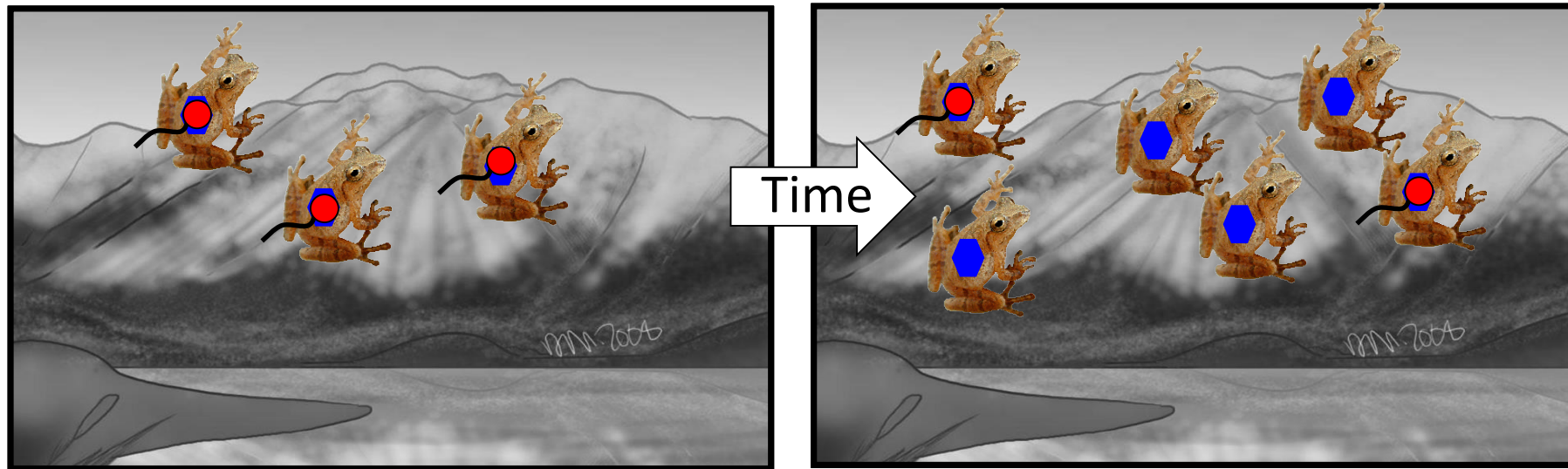
- ✓ Host recovery, low *Bd* prevalence
- ✗ Lower pathogen virulence
- Increased host resistance?



- ✓ Host recovery, low *Bd* prevalence
- ✗ Lower pathogen virulence
- ✓ Increased host resistance

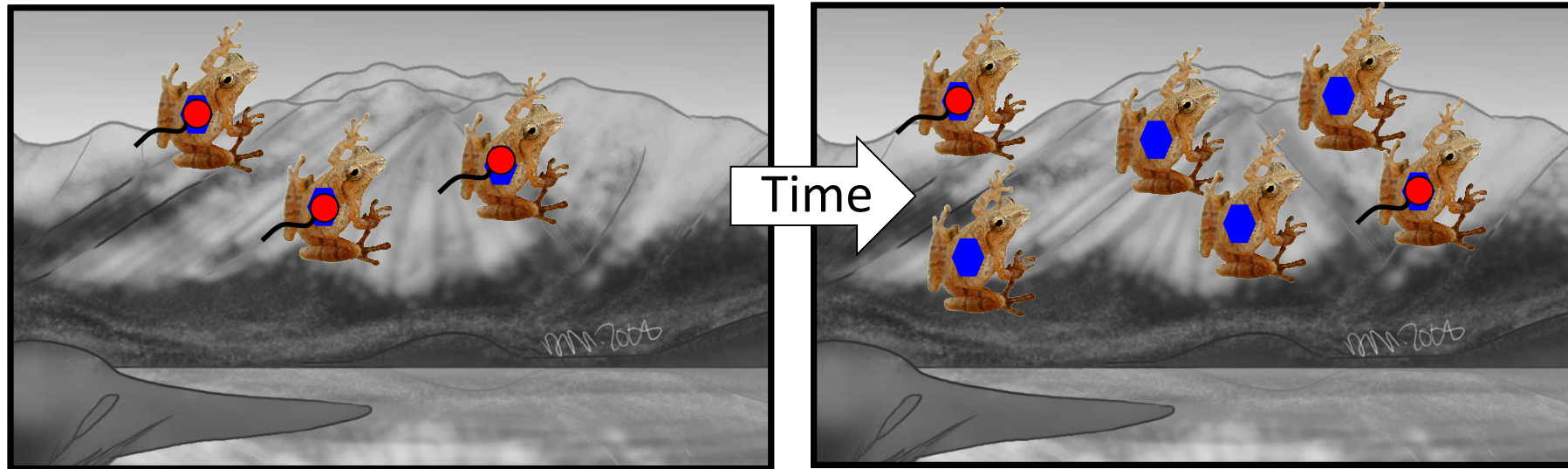
Disease rarely ends in host extinction

Disease rarely ends in host extinction



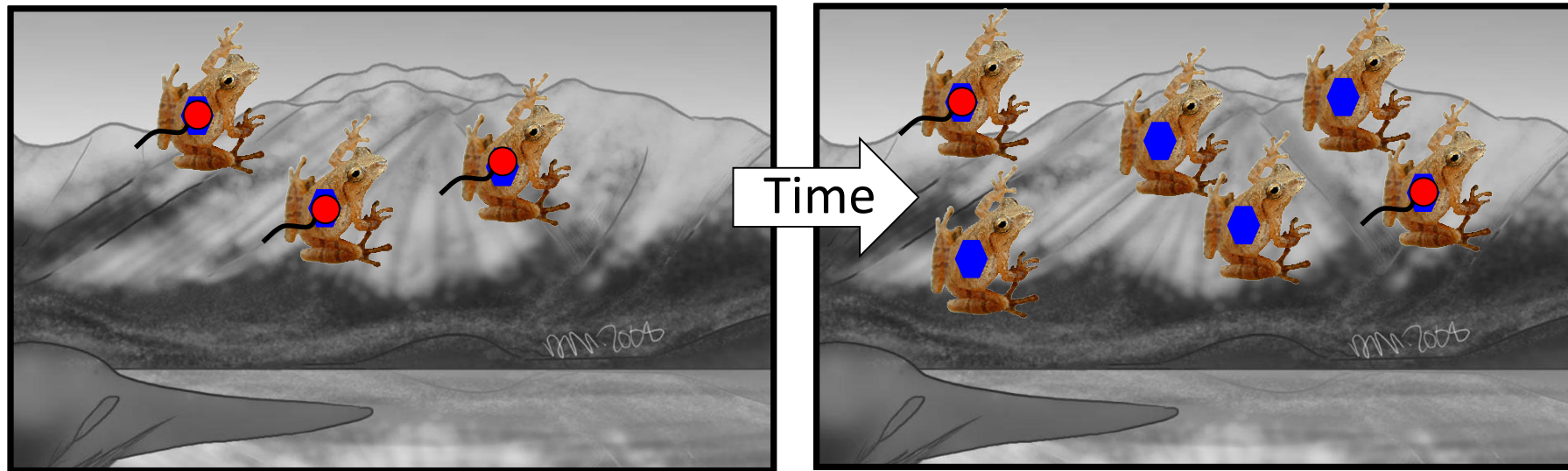
Some host species are recovering

Disease rarely ends in host extinction



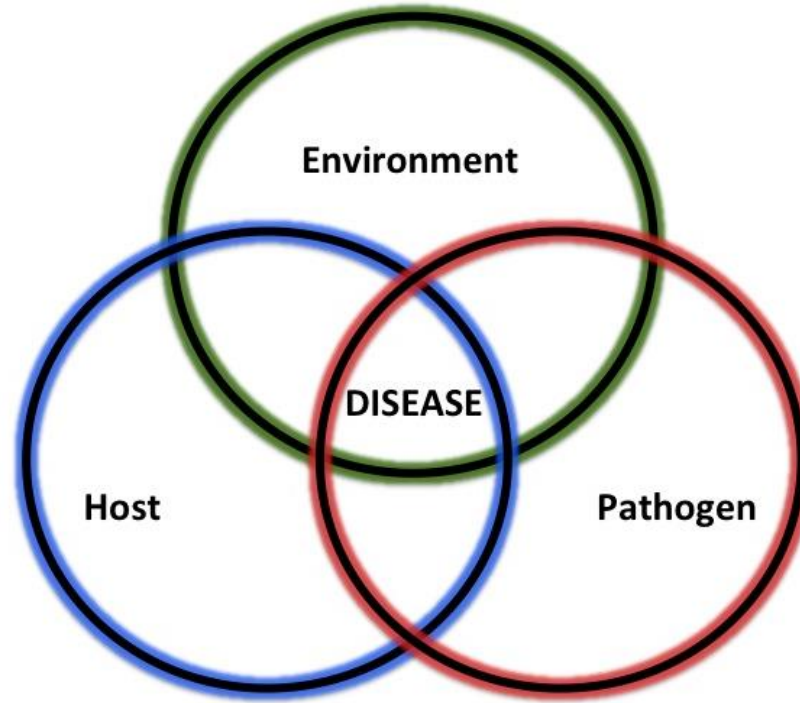
Some host species are recovering
Bd is equally pathogenic today

Disease rarely ends in host extinction



Some host species are recovering
Bd is equally pathogenic today
Shift in host responses

Disease rarely ends in host extinction



Some host species are recovering
Bd is equally pathogenic today
Shift in host responses

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