Ecology of Ranavirus:
a [complex] context-dependant relationship

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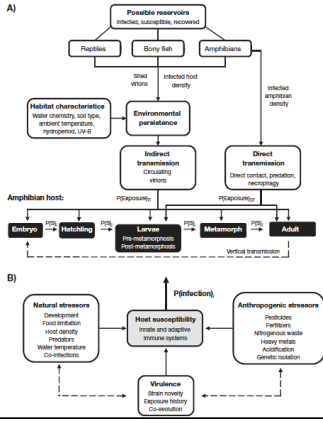


Ecology of Ranavirus

① Immediate Environment: the Host
-Developmental Instability
-Context-dependant infection

② Further Environment: Anthropogenic Effects
-Habitat Fragmentation
-Trace Metal Pollution

③ Transmission

Part 1 – The Host Environment

- Pathogens have important effects on host life-history traits

- Developmental instability (DI) occurs when individuals are unable to maintain stable development due to environmental stress (Møller, 1997; Palmer and Strobeck, 1986)
- Measuring DI using fluctuating asymmetry (FA) (Møller & Swaddle, 1997)

Debate Surrounding FA

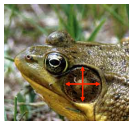
- Conflicting data
  - Significant
    - Hedrickx *et al.*, 1997 (Wolfe spider)
    - Lagesen and Folstad, 1998 (Reindeer)
  - Non-significant
    - Kimball *et al.*, 2003 (Red junglefowl)
    - Bosch and Márquez, 2000 (Midwife toad)

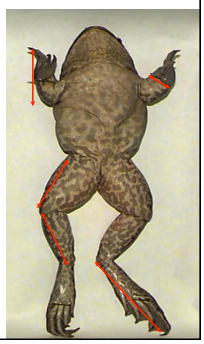
Methods

- Green frog (*Rana clamitans*)
- 11 sites
- ~25 individuals/site
- Euthanized and frozen

Measurements

- 7 measurements
- 3 repeats/measurement
- Sexual (2) and non-sexual (5) traits





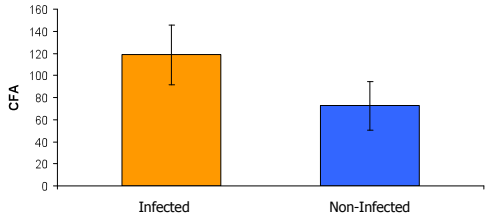
No difference in the levels of FA between males and females (p = 0.37)

No difference between the levels of FA in sexual and non-sexual traits (p > 0.1)

Individual Population FA

- 4 populations show significantly higher FA levels (13%-63% infection rates)
- 7 populations did not show significant FA results
  - 3 populations had 0% infection rate
  - 4 had low infection rates (<9%)

Overall FA

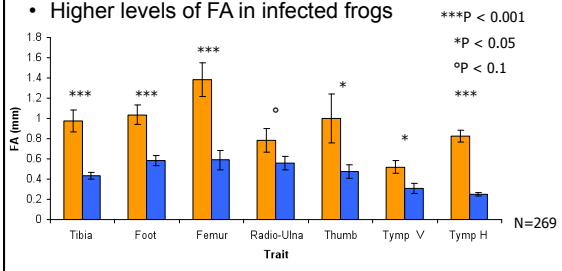


P < 0.001

N=269

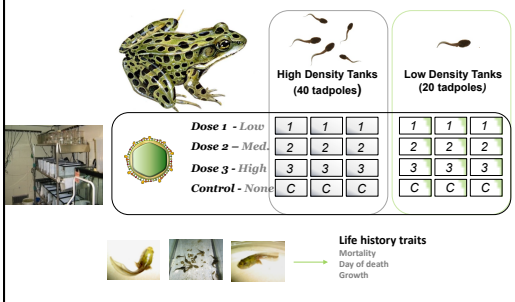
Individual Trait FA

- Higher levels of FA in infected frogs

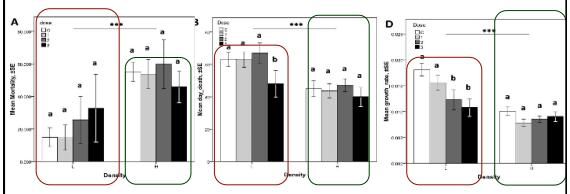


St Amour et al. 2010

Density of Hosts



Ranavirus virulence is density-dependent



Dose increase / decrease fitness

High density conceals the effects

Echaubard et al. 2010

Part 2 - Anthropogenic Effects

- Role of human disturbance in relation to disease prevalence in many animals (Daszak et al., 2004; Weldon et. al., 2004; Garner and Fisher, 2007; Bradley and Altizer, 2007)
- Humans' role in amphibian declines is well documented
- Amphibian EIDs and anthropogenic activity?

Environmental variation

- 11 sites
- 25 Green frogs/site
- 4 variables:
  - Distance to Roadway (m)
  - Distance to Housing (m)
  - Distance to Industry (m)
  - Ordinal scale based on 5 categories

Human Disturbance

- 5 categories- Presence or Absence (1-5), within one kilometer

1. Human activity
2. Recreation
3. Development
4. Agricultural activity
5. Industrial activity

Anthropogenic Activity

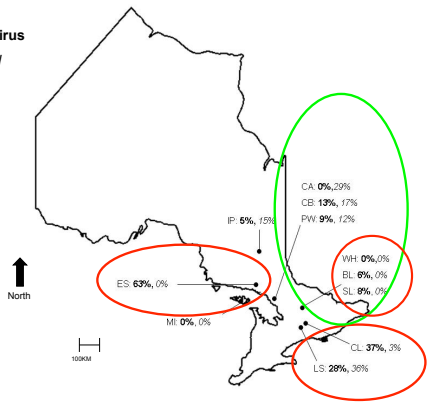
Table 1- Levels of anthropogenic activities in eleven Ontario green frog populations. All distances are measured in meters. See text for details on the calculation of human disturbance.

Site	Type	Human Disturbance Index	Distance to Road	Distance to Industry	Distance to Housing
CB	stream	3	129	1,400	567
SL	lake	2	1,400	65,300	29,900
BL	lake	2	758	64,600	29,600
PW	marsh	4	27	421	49
CL	lake	5	56	120	132
LS	lake	5	5	5	400
ES	marsh	5	7	5,100	67
IP	pond	2	179	750	316
MI	marsh	2	79	927	724
WH	pond	1	4,000	74,000	4,200
CA	pond	2	50	2,600	211

➔ Sites, disturbance index and anthropogenic influences are quite diverse

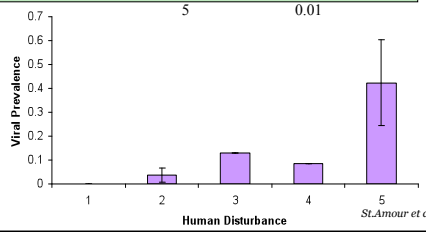
Ranavirus

Chytrid



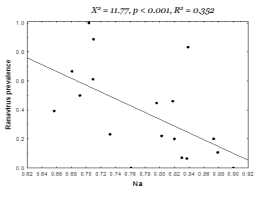
Human Disturbance and Prevalence

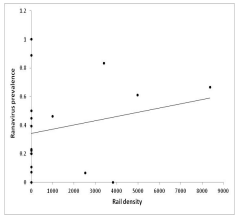
	d.f	MS	F
Intercept	1	0.06	8.47*
Human Disturbance	1	0.24	35.35**
Distance to Road	1	0.03	4.11˚
Distance to Industry	1	0.06	8.82*
Distance to Housing	1	0.06	8.08*
Error	5	0.01	



St.Amour et al. 2008

Habitat Fragmentation





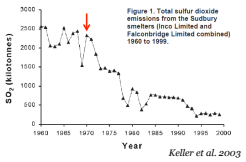
Low genetic variability → ***High Ranavirus prevalence***

High fragmentation, poor habitat → ***High Ranavirus prevalence***

Metal Pollution

Cu Effects on Amphibians and Fish

- ↑ in cutaneous mucal output
- cardiac, respiratory, and neuromuscular disorders



Keller et al. 2003

SO_2 acidification of lakes and wetlands (~17,000km^2)

(Dixit et al., 1992b; Matuszek et al.,38 1992; Keller et al., 2004)

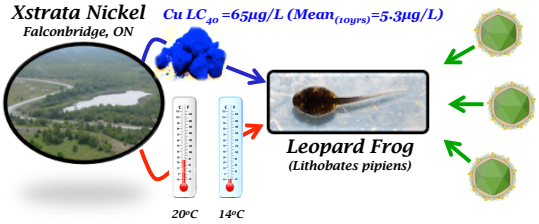
2002 Suspended Particulate Discharge (in Tonnes)

Nickel	1400
Copper	210

(CEM, Unpub. data, 2002)

Xstrata Nickel
Falconbridge, ON

Cu LC_{40} =65µg/L (Mean$_{(10yrs)}$=5.3µg/L)



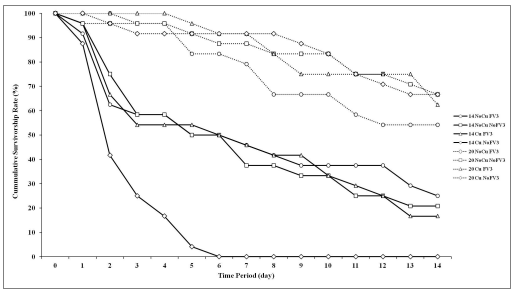
Leopard Frog
(Lithobates pipiens)

20°C ***14°C***

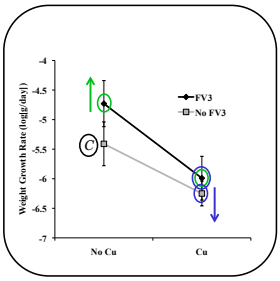
Design

-5 Replicates
-10 tadpoles/replicate
-Effluent Water (250mL/tad)
-Dried food (150mg/tad)

Survival



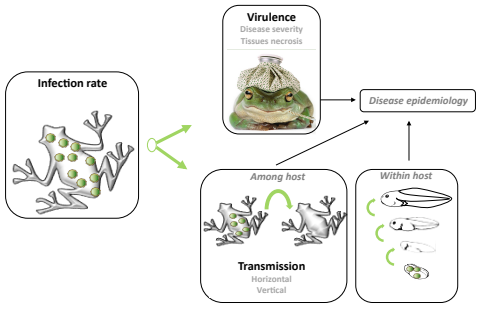
Growth

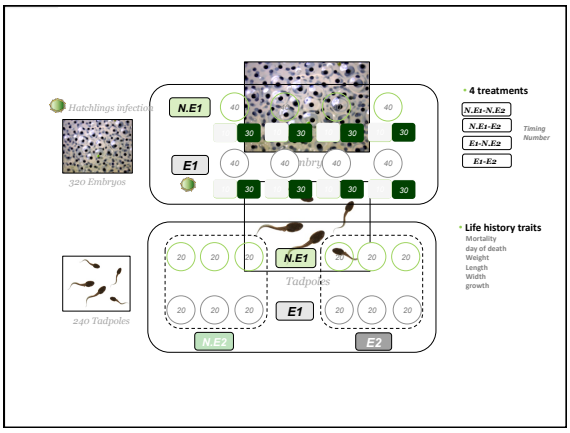


Cu: $F_{(1,77)}$=13.15 P=0.001

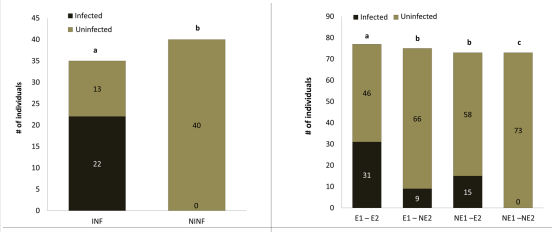
FV3: $F_{(1,77)}$=3.03 P=0.07

Part 3 - Transmission

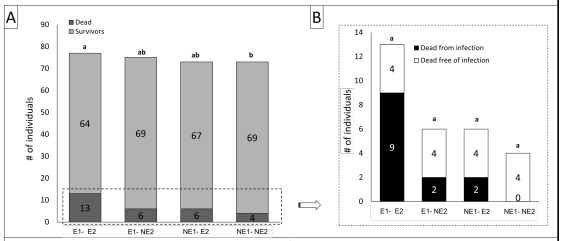
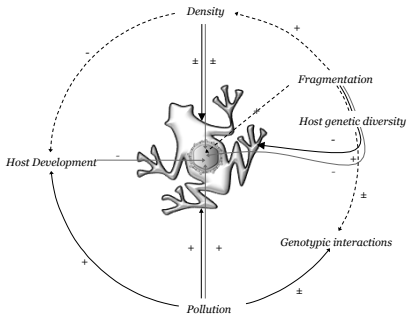




Infection Rates



Mortality Rates



Complex Ecological Relationships….