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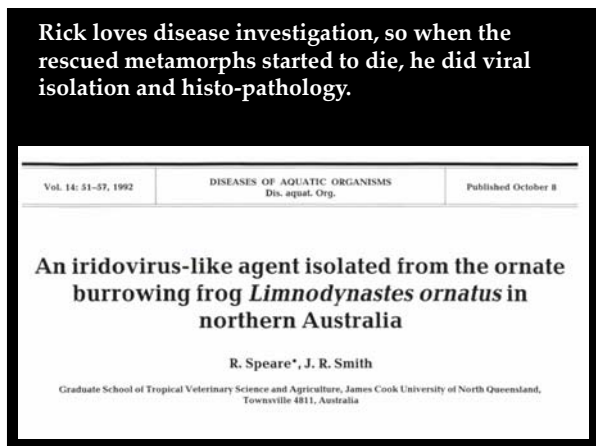
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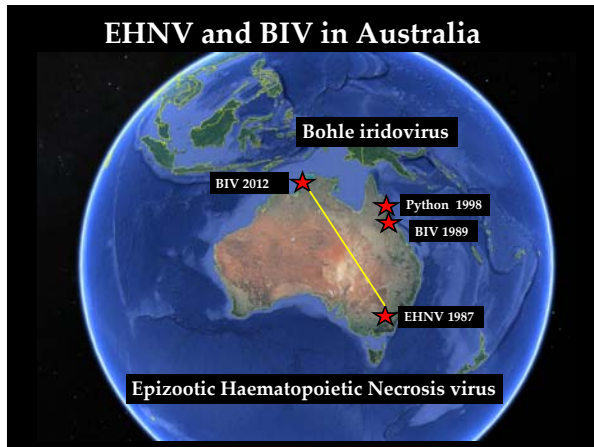
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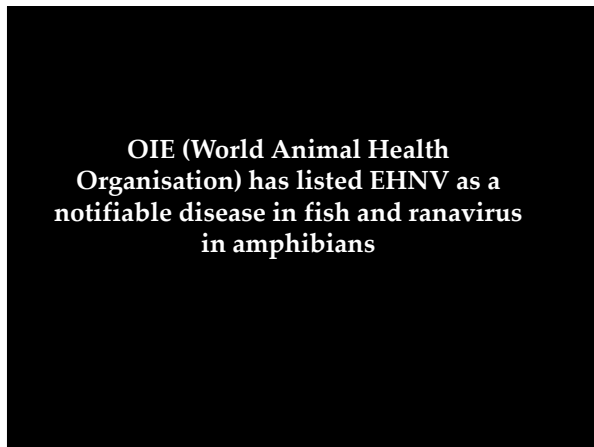
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OIE (World Animal Health Organisation) reference laboratory for EHN<sub>V</sub> and ranavirus is based in Australia

Dr Nick Moody  
Australian Animal Health Laboratory  
Geelong Victoria 3220  
AUSTRALIA  
Email: [nick.moody@csiro.au](mailto:nick.moody@csiro.au)

Dr Richard Whittington  
University of Sydney  
Faculty of Veterinary Science  
Camden NSW 2570  
AUSTRALIA  
Email: [rjchardw@camden.usyd.edu.au](mailto:rjchardw@camden.usyd.edu.au)

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### Challenge trials

Jeremy Langdon 1989  
EHN<sub>V</sub> trials  
11 teleosts

Leigh Owens  
BIV trials  
Student projects:  
fish, crustaceans  
amphibians and reptiles

Joy Becker 2013  
EHN<sub>V</sub> trials  
12 freshwater fish spp

Moody 1994 Barramundi  
Cullen 1995 Frogs  
Ariel 1997 Tilapia  
Ariel 2015 Crocodiles,  
snakes and turtles

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### Challenge trials EHN<sub>V</sub>

In addition to redfin perch (*Perca fluviatilis*) and rainbow trout (*Onchorhynchus mykiss*), the original hosts for EHN<sub>V</sub>, several species of freshwater fish were found to be susceptible:

**Langdon 1989**  
Macquarie perch (*Macquaria australasica*), silver perch (*Bidyanus bidyanus*), mountain galaxias (*Galaxias olidus*) and mosquito fish (*Gambusia affinis*).

**Becker et al 2013**  
Murray-Darling rainbowfish (*Melanotaenia fluviatilis*), Dewfish (*Tandanus tandanus*), Eastern mosquitofish (*Gambusia holbrooki*), Silver Perch (*Bidyanus Bidyanus*) and Macquarie Perch (*Macquaria australasica*)

While others appeared to be refractory or with low mortality

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## Challenge trials BIV

**Amphibians:** *Bufo marinus* and a range of native species (*Limnodynastes*, *Litoria*, *Pseudophryne*, *Taudactylus*) could be infected with BIV, but mortality variable (Cullen et al 1995; Cullen & Owens 2002)

**Fish:** mortality in barramundi (*Lates calcarifer*); infect tilapia (*Oreochromis mossambicus*) (Moody & Owens 1994; Ariel & Owens 1997)

**Reptiles:** kill tortoise hatchlings (Ariel 1997)  
– *Euseya latisternum* & *Emydura krefftii*

Juveniles more susceptible

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## Host susceptibility to disease

- Important to distinguish between infection versus disease
- Susceptibility to disease depends on life stage
  - > for larvae and metamorphs, low for adults
- The susceptibility depends on host species
- Susceptibility is not predictable from host taxonomy

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## Bioassay for virus refractory to cell culture

Enveloped virus



Barramundi live



Naked virus



Barramundi dead



Tilapia live



Tilapia dead



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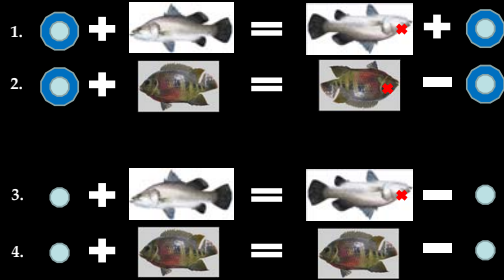
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## Bioassay for virus refractory to cell culture



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Richard Whittington

## Pathology

"Apparent tropism for vascular endothelium and widespread multi-organ necrosis and/or haemorrhage, especially involving haematopoietic tissues."

### EHN in fish

Reddacliff and Whittington 1996

### BIV in frogs

Jerret et al 2015

### BIV in turtles

Ariel et al 2015

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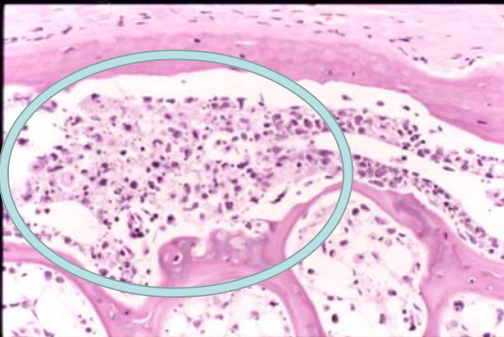
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Kidney with necrosis of haemopoietic tissue



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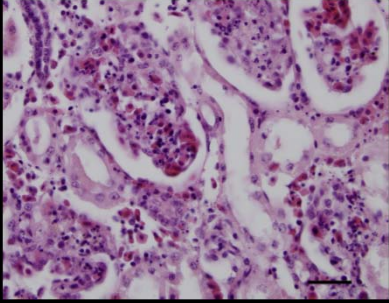
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Kidney with necrosis of glomerular mesangium



Jerret et al 2015

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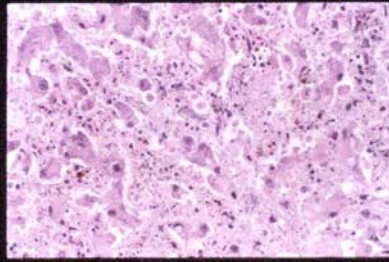
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Liver with necrosis



- Pathology is usually extensive in fatal cases
- Many organs damaged

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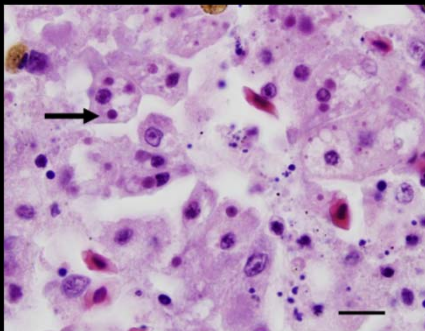
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Basophilic inclusion bodies liver



Jerret et al 2015

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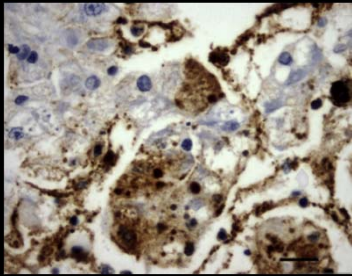
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Antigen of BIV can be detected by IHC



Jerret et al 2015

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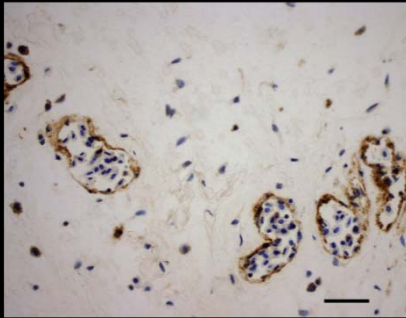
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Stomach submucosa – venular epithelium labelled



Jerret et al 2015

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## Ranavirus pathology

- Widespread focal necrosis in many organs ± haemorrhage
- Animals die from “organ failure”, but pathophysiology is not understood

**Makes treatment difficult!**

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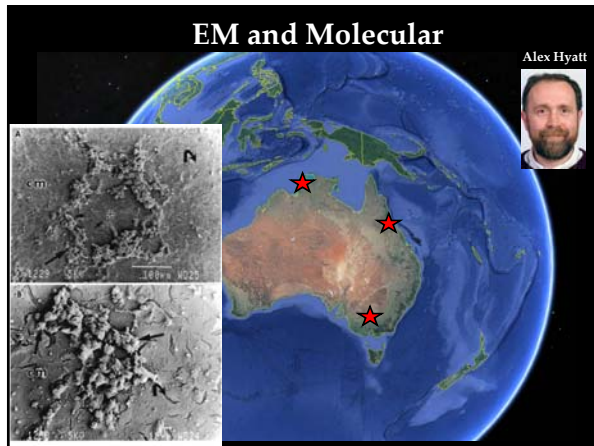
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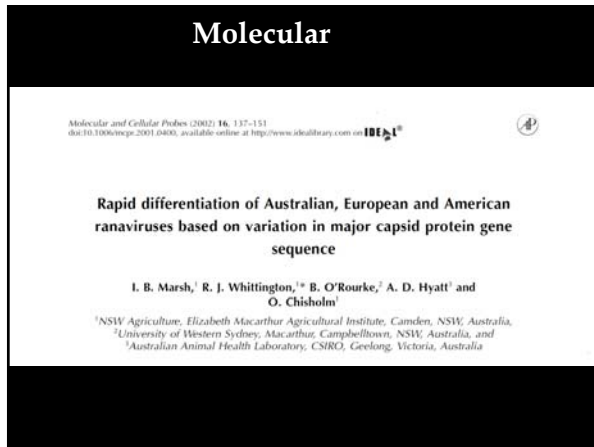
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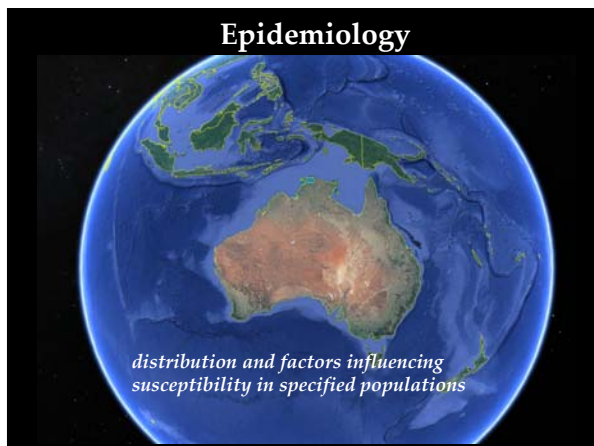
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## Distribution of anti-ranaviral antibodies in introduced *Bufo marinus*



Overall prevalence  
2.7%

Regional range  
0-13%

**Ranavirus antibodies common in freshwater turtles & freshwater crocodiles in NQld**

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## Epidemiology EHN

- EHN is poorly infective but highly virulent in rainbow trout
- may be found in trout in all age classes
- need not be associated with clinically detectable disease in the population
- can be transferred with shipments of live fish
- can be detected in a small proportion of 'routine' mortalities
- may be associated with specific antibodies in a small proportion of older fish

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## Epidemiology EHN

- The origins of the virus are unknown
- means of spread may include the intentional movement of live or dead fish
- the mechanical transfer on boats, nets and other equipment
- spread through flowing water
- migrating carrier fish in a catchment area
- potentially, mechanically by piscivorous birds




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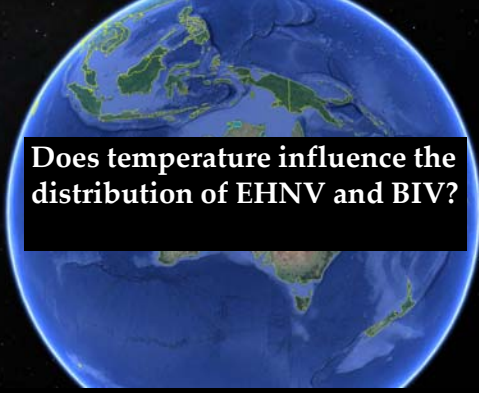
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**Epidemiology temperature**



**Does temperature influence the distribution of EHNV and BIV?**

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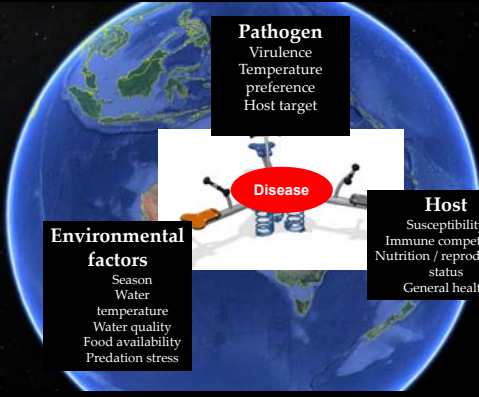
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**Epidemiology temperature**



**Pathogen**  
Virulence  
Temperature preference  
Host target

**Host**  
Susceptibility  
Immune competence  
Nutrition / reproduction status  
General health

**Environmental factors**  
Season  
Water temperature  
Water quality  
Food availability  
Predation stress

**Disease**

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**Co-infections**

- Recent hypotheses that ranaviruses may be devastating to amphibian populations already compromised by endemic chytridiomycosis.
- The impact of these two pathogens (and others) certainly needs more clarification in a range of environments and populations.

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## Epidemiology is dynamic

- Epidemiology / ecology is complex
- Multiple hosts of different susceptibilities interacting with local environment
- Environmental persistence of pathogen and role for acquired immunity
- Global trade in ornamentals is probably a huge facilitator of spread

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## Disinfection and Prevention

OIE guidelines for surveillance and prevention of spread  
Field hygiene protocols Speare et al 2004  
Research into disinfection methods

### Ultraviolet sterilisation of model viruses important to finfish aquaculture in Australia

I MIOCEVIC, J SMITH, L OWENS AND R SPEARE  
Graduate School of Tropical Veterinary Science and Agriculture,  
James Cook University, Townsville Queensland 4811

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BIOLOGICAL CONSERVATION 141 (2008) 2387–2394



available at [www.sciencedirect.com](http://www.sciencedirect.com)



journal homepage: [www.elsevier.com/locate/biocon](http://www.elsevier.com/locate/biocon)



### Mass mortality of native anuran tadpoles in tropical Australia due to the invasive cane toad (*Bufo marinus*)

Michael R. Crossland<sup>a</sup>, Gregory P. Brown<sup>a</sup>, Marion Anstis<sup>b</sup>, Catherine M. Shilton<sup>c</sup>, Richard Shine<sup>a,\*</sup>

<sup>a</sup>School of Biological Sciences A68, University of Sydney, Sydney, NSW 2006, Australia

<sup>b</sup>26 Widricrow Road, Benoura Heights, NSW 2082, Australia

<sup>c</sup>Department of Primary Industries, Fisheries, and Mines, Berrimah Veterinary Laboratories, Darwin NT 0801, Australia

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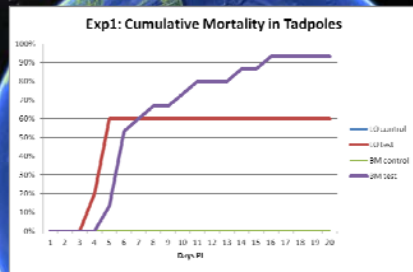
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## Biological control weapon?



LO = *Limnodynastes ornatus*; BM = *Bufo marinus*

Mortality variable in adult toads

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## Biological control weapon against invasive cane toads?



Animal Conservation

ZSL

Animal Conservation, Print ISSN 1367-9430

### Biological control of the cane toad in Australia: a review

T. Shanmuganathan<sup>1</sup>, J. Pallister<sup>2</sup>, S. Doody<sup>2</sup>, H. McCallum<sup>1</sup>, T. Robinson<sup>1</sup>, A. Sheppard<sup>3</sup>, C. Hardy<sup>1</sup>, D. Halliday<sup>1</sup>, D. Venables<sup>1</sup>, R. Voysey<sup>2</sup>, T. Strive<sup>1</sup>, L. Hinds<sup>1</sup> & A. Hyatt<sup>4</sup>

<sup>1</sup>CSIRO Entomology, Black Mountain Laboratories, Acton, ACT, WA, Australia

<sup>2</sup>CSIRO, Australian Animal Health Laboratory, Geelong, Vic., Australia

<sup>3</sup>Department of Botany and Zoology, Australian National University, Canberra, ACT, WA, Australia

<sup>4</sup>School of Zoology, University of Tasmania, Hobart, Tas., Australia

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... and what is next?



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Thanks for listening  
- references on line



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