Koi herpesvirus: its potential as a biological control agent for carp in Australia

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Koi herpesvirus – the disease

• First described outbreaks in Israel in 1998
• Now worldwide distribution
  • Not yet in Australia (exotic disease!)
• High mortality (70-100%) in all age groups of carp
  • Common carp (*Cyprinus carpio carpio*)
  • Koi carp (*C carpio koi*)
  • No other species affected

• Transmission
  • Horizontal – low levels of virus required
  • Vertical - ?
Koi herpesvirus – the disease (cont.)

- **Outcome of infection is temperature-dependent**
  - Max. losses when water temp: 17° – 26°C
  - Most outbreaks in Spring

- **Pathogenesis**
  - Entry site: Skin
  - Systemic infection -> excretion via gills, faeces, urine
  - Death due to loss of function of gills, kidney, gut

- **Re-named ‘Cyprinid herpesvirus-3’ (CyHV-3)**
  - CyHV-1: mortality, “carp pox”
  - CyHV-2: goldfish haematopoietic necrosis virus
Therefore,

- **Specificity** of the virus
- **Sensitivity** of the target species
- **High mortality** in the target species
- Wide **age-range** of affected species

All of these factors suggest that KHV may potentially be a good biological control agent for carp in Australia

- Chose an Indonesian isolate of KHV
Koi herpesvirus – achievements

Introduced a range of technical procedures

- Viral culture systems
  - KF-1 cell line
- Immunohistochemistry / immunocytochemistry
- Molecular detection methods
  - No. of KHV-specific conventional PCRs
  - KHV-specific TaqMan assay
- Electron microscopy
Koi herpesvirus – achievements

• Does KHV kill Australian carp?

  • Australian wild carp are susceptible to KHV
    • Mortality is dose-dependent, and size-dependent
KHV-induced mortality in juvenile carp

Days post challenge

% mortality

- Negative control
- IP (~10 TCID50/fish)
- Bath (0.6 TCID50/mL)
- Bath (6 TCID50/mL)
- Bath (30 TCID50/mL)
KHV – lesions in carp

Gill necrosis

Skin necrosis
Koi herpesvirus – achievements

• Does KHV kill Australian carp?
  • Australian wild carp are susceptible to KHV
    • Mortality is dose-dependent, and size-dependent
Koi herpesvirus – achievements

• Does KHV kill Australian carp?
  • Australian wild carp are susceptible to KHV
    • Mortality is dose-dependent, and size-dependent
    • Larvae
      • Japanese work
    • Juveniles
      • Course of disease is temperature-dependent
      • Very short clinical course
      • High mortality
    • Mature fish (20-30 cm)
      • Lower % mortality?
      • Carp-goldfish hybrids
Koi herpesvirus – achievements

• Susceptibility issues
  1. Carp-goldfish hybrids have lower mortality
     • Serendipitous results
Characterization of fish in a KHV challenge trial

• Fish that **died** following challenge with KHV
  • 5/5 bath-infected mortalities were carp
  • 2/2 IP-inoculated mortalities were carp

• Fish that **survived** following challenge with KHV
  • 3/5 bath-infected survivors were hybrids
  • 7/7 IP-inoculated survivors were hybrids
Koi herpesvirus – achievements

• **Susceptibility issues**
  1. Carp-goldfish hybrids have lower mortality
     • Serendipitous results
     • Conflicting results in the literature
     • Need data on the prevalence of hybrids
       • Collaborate with Paul Brown, Fisheries Victoria
       • Molecular approach using 12S nuclear gene
  2. Survey wild carp for cyprinid herpesviruses
     • Test for viruses cross-reactive with KHV
     • Nursery ‘hot spots’ in the M-D Basin
       • Collaborate with Dean Gilligan, NSW Fisheries
       • Molecular approach using a viral DNA polymerase gene
Koi herpesvirus – achievements

• Does KHV affect native fauna?
  • Tested susceptibility of:
    • Murray cod, golden perch, silver perch (*Bidyanus bidyanus*)
  • Infected by immersion, and by IP inoculation
    • Dose of IP virus: $10^2$-$10^3$ times greater than min. req’d to induce disease in carp
    • Held for 28 days post exposure to KHV
    • Looked for evidence of virus (PCR) and tissue damage (histopathology)
    • Carp used as positive controls

• No evidence of virus replication or disease in non-target species
Koi herpesvirus – future activities

- Epidemiology of KHV infection
  - Aim: understand the spread and persistence of KHV in carp and the environment
    1. Sensitivity to infection
      - Carp extraordinarily sensitive to KHV
      - Useful to have data on precise sensitivity for specific age-groups
      - Targeted release of virus
    2. Excretion of KHV
      - The dynamics/amount of virus produced by an infected carp
      - Completed one trial to supply preliminary information
Koi herpesvirus – future activities

Epidemiology of KHV infection (cont)

3. Survey wild carp for cyprinid herpesviruses
   • Most samples collected
   • Lab analysis ready to begin

4. Estimate the prevalence of hybrid carp in Victorian waters
   • All samples collected
   • Lab analysis has now begun

5. Further non-target species testing
   • Families Galaxiidae, Salmonidae
Teleosts

- Tetraodontiformes
- Pleuronectiformes
- Perciformes
- Scorpaeiformes
- Synbranchiformes
- Gasterosteiformes
- Zeiformes
- Beryciformes
- Stephanoberyciformes
- Cyprinodontiformes
- Beloniformes
- Atheriniformes
- Mugiliformes
- Lophiiformes
- Batrachoidiformes
- Gadiformes
- Ophidiiformes
- Percopsiformes
- Polymixiiformes
- Lampridiformes
- Myctophiformes
- Aulopiformes
- Ateleopodiformes
- Stomiiformes
- Salmoniformes
- Osmeriformes
- Esociformes
- Gymnotiformes
- Siluriformes
- Characiformes
- Cypriniformes
- Gonorrhynchiformes
- Clupeiformes
- Saccopharyngiformes
- Anguilliformes
- Albuliformes
- Elopiformes
- Osteoglossiformes

Murray cod, G perch, S perch

Salmon, trout

Galaxiids
Koi herpesvirus

• Potential as a biological control agent for carp in Australia
  • Early days yet, but........
    • Targeted, strategic release
    • Used in conjunction with other carp control procedures