

## Nematodes

- Most abundant multicellular organism on earth
- 80,000 described species
- Inhabit extreme locations  
Antarctica and deep ocean trenches
- One acre of fertile topsoil contains billions of nematodes



[www.usda.gov](http://www.usda.gov)

## Nematodes

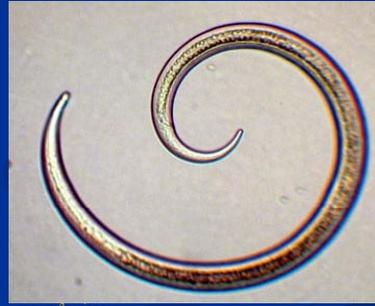
- Most are free-living and microscopic
- >5,000 species are parasitic to vertebrates
- Largest ever recorded 28 feet long (width of a pencil)



[www.berguata.org](http://www.berguata.org)

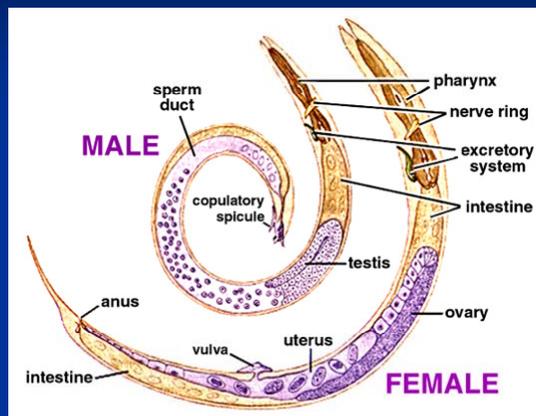
# Nematodes

- Unsegmented, body shape is elongate (whip-like), with rigid cuticle covering body
- Indirect life cycles
  - Invertebrates
  - Fish
    - Larval forms
      - Muscle
    - Adults
      - G I Tract



[www.reelkeeping.com](http://www.reelkeeping.com)

# Nematode

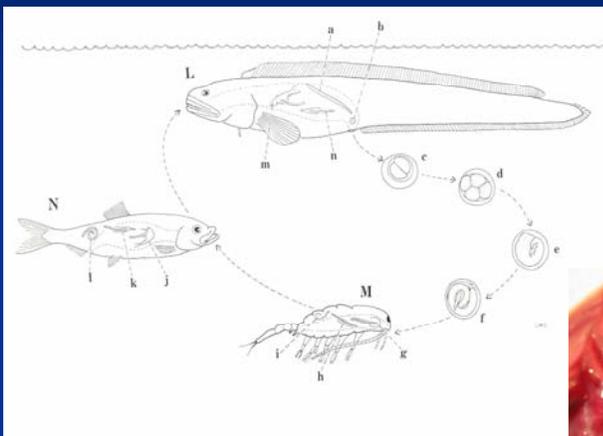


[www.cals.ncsu.edu](http://www.cals.ncsu.edu)

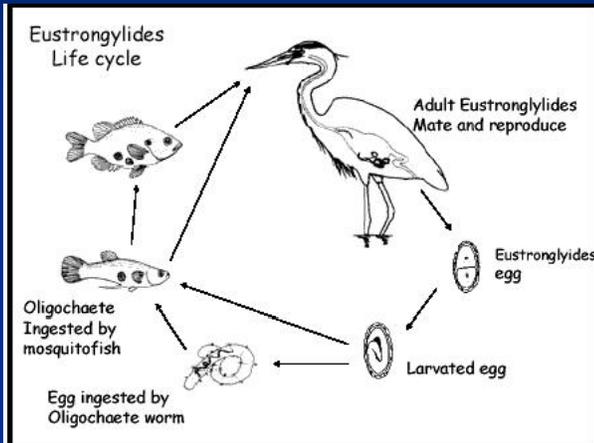
## Larval Nematodes in Fish - *Anisakis* spp.



## *Contracaecum* – larval form in fish



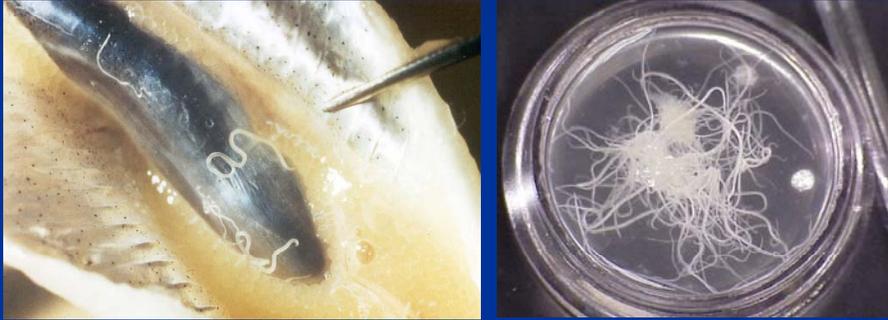
## Larval form in Fish - *Eustrongylides*



## Adult forms in Fish – *Camallanus*



**Adult forms in Fish – *Cystidicola***



**Adult forms in Fish – *Philometra***

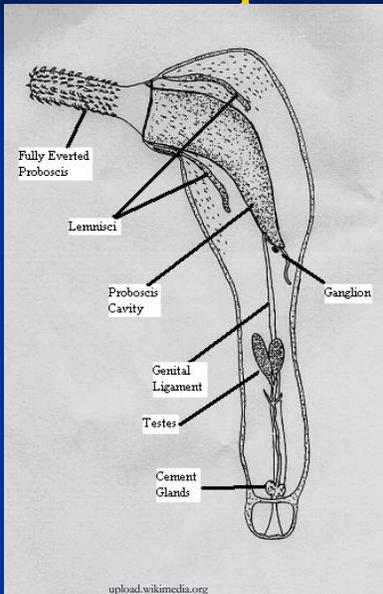


## Acanthocephala-Spiny-headed worms

- Characterized by anterior hook-bearing proboscis (species id by number, size and arrangement of hooks)
- Indirect, complex life cycle
- Primarily found as adults in the intestinal tract of fish



## Acanthocephalans



# Acanthocephalans

## ■ Affect host behavior

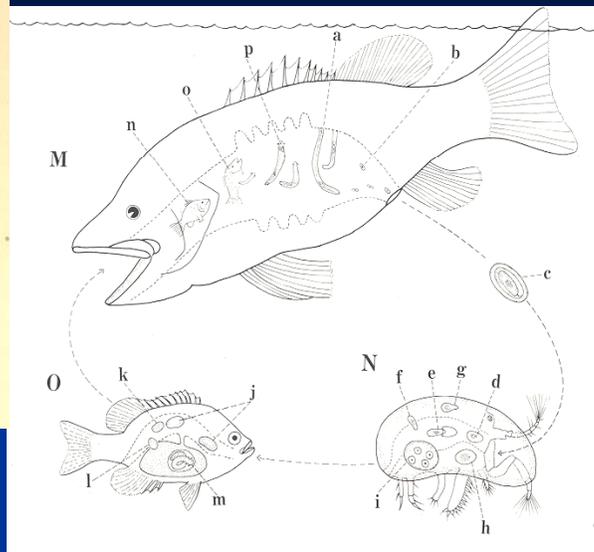
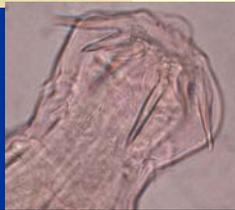
### ■ *Gammarus lacustris*

- Increases levels of serotonin
  - Causes Gammarus to become attracted to light
  - Swims near surface making it easier prey for ducks



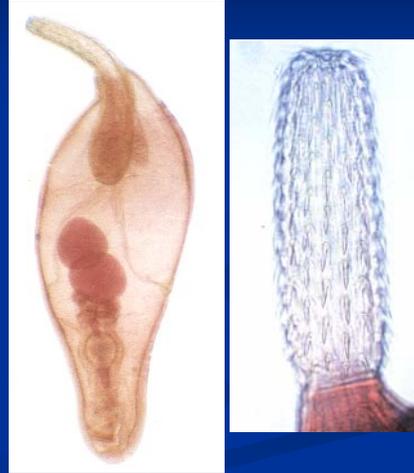
schmidling.com

## Adult Acanthocephala in fish - *Neoechinorhynchus*



## Adult Acanthocephala in fish - *Metechinorhynchus*

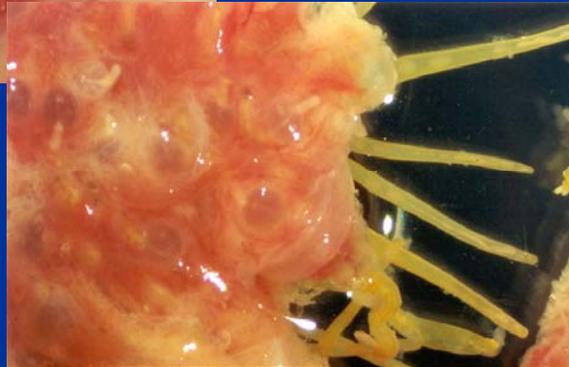
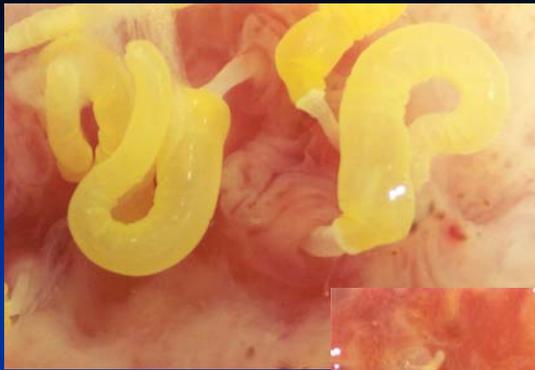
- Chinook Salmon
- Damage Intestinal Tract
- Reproductive Problems
  - Selective Vitamin Absorption
  - Eggs are deficient
  - Abnormal Development



## Adult Acanthocephala in fish - *Metechinorhynchus*

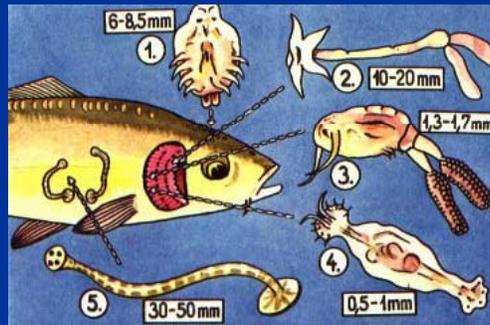


**Adult Acanthocephala in fish – *Pomphorhynchus***

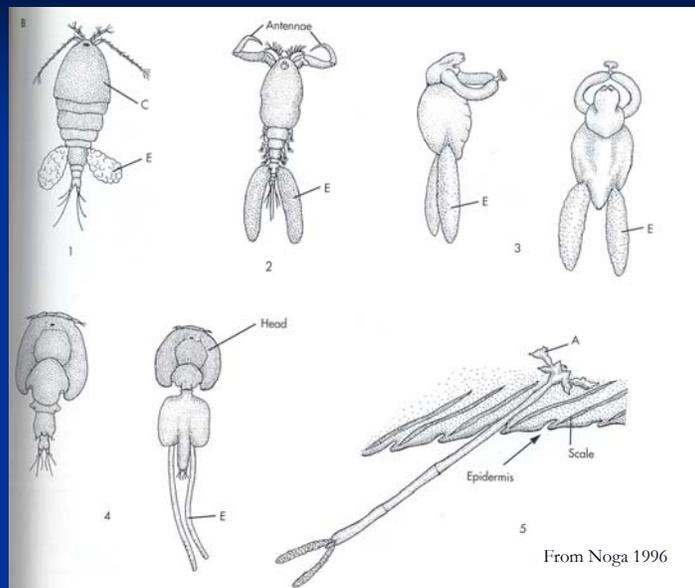


## Crustaceans – Branchiurans & Copepods

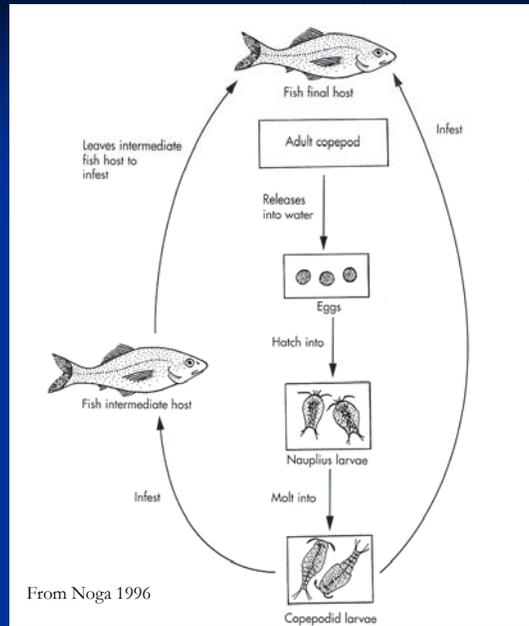
- Very variable in appearance: “lice-like,” “grub-like,” or “worm-like”
- Direct life cycles, primarily ectoparasites, either mobile or permanently embedded
- Serious pests, especially in hatcheries and cage-culture



## Parasitic Copepods



## Parasitic Copepods – Life Cycle



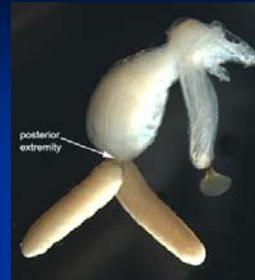
## *Ergasilus* spp.

- Freshwater and Marine
- 2° Antennae Modified
- Feed Heavily on Tissue and Mucus
- Damage gill tissue
- Provide entry for bacteria and fungi
- Chemical Treatments



## *Salmincola*

- Gill, Mouth and Fin
- Can cause damage to hatchery stocks
- Permanently anchored by Bulla in bone or cartilage
- Hatchery Infections
  - Difficult to control
  - Water supply must be free of the parasites
  - *Salmincola*/Eggs cannot withstand drying out



*Salmincola edwardsii*

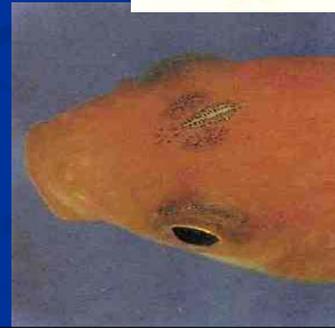


## *Salmincola* spp. and *Actheres* spp.



## Branchiuran Fish Louse – *Argulus*

- Moves freely feeding on blood mucus and epithelial cells
- Saucer Shaped
- Can cause fish kills in lakes and ponds
- Can transmit diseases
- Chemical Treatments



## Sea Lice – *Lepeophtheirus* and *Caligus* Marine

- Atlantic salmon, Pacific salmon, sea trout, steelhead, Arctic char
- Commercially damaging
  - major economic losses
  - Reduce growth and cause external damage
  - Reduces value and marketability
  - Death



[www.puresalmon.org](http://www.puresalmon.org)

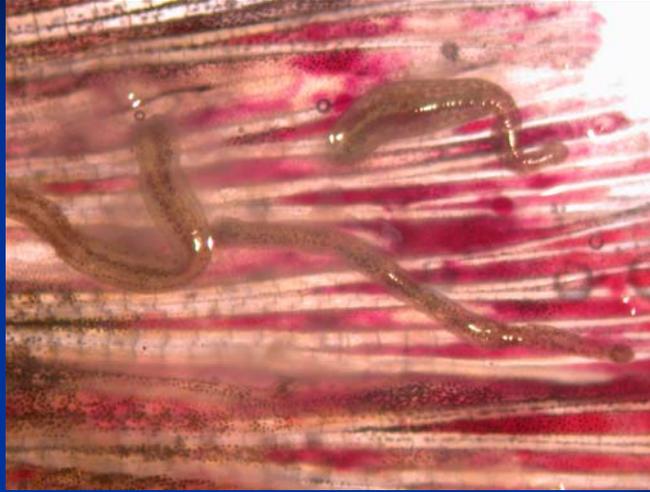
## Lernea - The Anchor Worm

- 22 mm in length
- Infest numerous species
  - Can infect frogs and salamanders
- Horns embed deeply under scales
- Can provide entry for bacteria and fungi
- Can kill small fish



## Annelids-Leeches

- Parasitic (feed on blood) and free-living forms (feed on vegetation, detritus, worms, etc.)
- Generally are elongate, flat, segmented, and with suckers on each end of the body
- Can serve as vectors of blood flagellates (*Cryptobia*), blood sporozoans and viruses (IHNV) (SVCV)
- May predispose fish to 2<sup>nd</sup> bacterial infections by providing “portals of entry”



Most parasitic fish leeches belong to Family Piscicolidae

## Fungal Diseases

- Ubiquitous in all water systems
- Secondary Invaders
  - Injury
  - Poor conditions
  - Disease
- Best Treatment is Prevention



## Fungal Diseases

### ■ Appropriate Conditions

- Oxygen
- Temperature
- pH
- Densities
- Cleanliness



earthwormenvy.files.wordpress.com

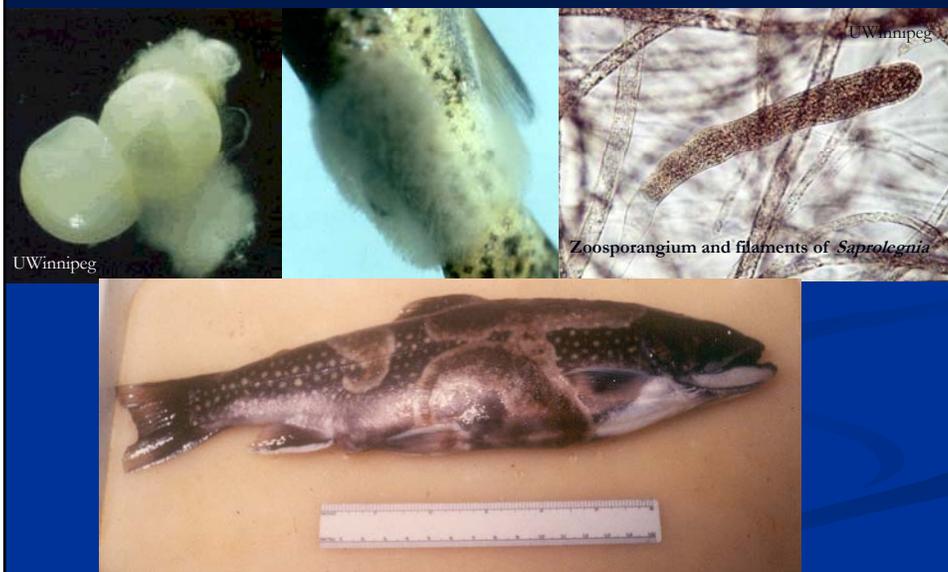
## Fungal Diseases

- *Saprolegnia*
  - Water Molds
  - most important fungal group affecting wild and cultured fish
- Ichthyophoniasis - *Ichthyophonus hoferi*
- Microsporideans

## Saprolegniasis

- Affects living and dead fish/eggs causing serious infections
- Eight genera reported: Saprolegnia, Achlya, Aphanomyces, Calptraheca, Thraustotheca, Leptolegnia, etc...
- Water molds are opportunistic (2<sup>nd</sup> pathogens), multiplying on fish that are injured, stressed or infected but can at times cause primary infections
- Can occur anywhere on the body, normally appears as conspicuous circular or crescent-shaped, white, cotton-like lesions

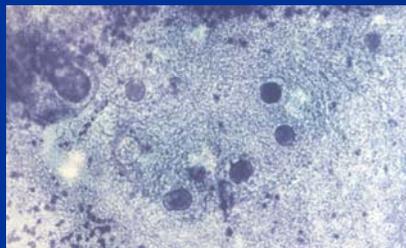
### *Saprolegnia* spp.



## Ichthyophoniasis – *Ichthyophonus hoferi*

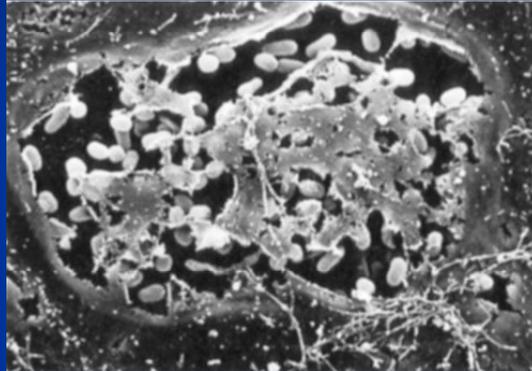
- Affects hatchery and wild fish (marine and FW)
- World-wide distribution and broad host specificity
- Disease signs: lethargy, emaciation, color changes, fluid accumulation, nervous disorders, externally the skin appears rough (“sand-paper effect”) and may have ulcers, skeletal deformities in salmonids, internally white or cream colored nodules or lesions in any organ
- Diagnosis: presence of spherical resting spores

## *Ichthyophonus*



## Microsporideans

- Atypical Fungi
- Small, Obligate Intracellular Parasites
  - 1-40  $\mu\text{m}$
  - Smallest Parasites
  - Lack Mitochondria



evolution-textbook.org

## Microsporideans

- Infect every animal species
  - Even single celled organisms
  - Parasites of parasites
- World-Wide
  - Many to be discovered
  - May outnumber animals
- Human pathogen
  - AIDS patients

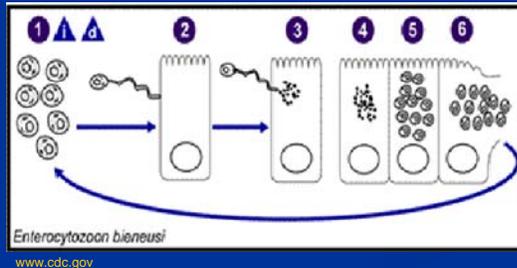


upload.wikimedia.org

# Life Cycle

## ■ Direct Lifecycle

- Sporoplasm enters cell through polar filament
- Sporogenesis



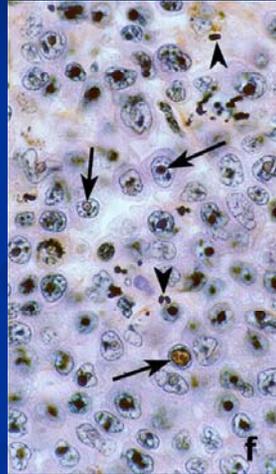
# *Nucleospora salmonis*

- Chinook Salmon
  - Pacific Northwest
- All salmonid species considered susceptible
- Reported from a variety of fish
  - Fresh and Saltwater



## *Nucleospora salmonis*

- Infects hematopoietic cells
- Signs of Disease
  - Pale gills
  - Enlarged Kidney/Spleen



Idaho Fish Health Center

## Control

- Fumagillin
  - Derived from *Aspergillus fumigatus*
  - Analog compound TNP-470
- Medicated feed
  - Fish showed signs of infection without mortality



© Rechtsanwalt Friedhelm Thome, Köln

## Control

- Minimize Stress
  - Crowding



[www.agriculture.state.pa.us/](http://www.agriculture.state.pa.us/)

## Current Studies

- Molecular Characterization
  - Where did Ns come from?
    - Compare Great Lakes isolate to Pacific, Atlantic, and European Strains
- Sampling Strategies
  - Nonlethal vs. lethal
  - Life Stages



## Current Studies

- Transmission
  - Horizontal
    - Cohabitation
    - Feeding
  - Vertical
    - Parent to offspring
- Control Measures
  - Possible Egg Treatments



[www.stjohnsloch.net](http://www.stjohnsloch.net)

## Current Studies

- Life Cycle
  - From infection through mortality
    - Determine tissues involved
    - Parasite Development
- Develop better diagnostic Techniques
  - Polymerase Chain Reaction (PCR)



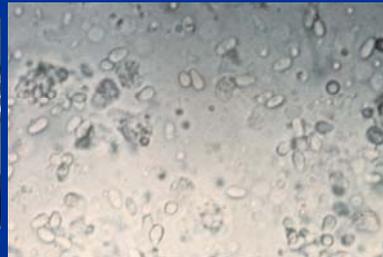
[www.molecularstation.com](http://www.molecularstation.com)

## Protozoans-Microsporidia

- Microsporidians are intracellular parasites that require host tissue for reproduction
- Replication within spores (schizogony) causes enlargement of host cells (hypertrophy).
- Infected fish may develop tumor-like masses or cysts (xenomas) in various tissues.
- Clinical signs can vary from no visible lesions to mortalities.
- Diagnosis is by locating spores in affect tissues (in wet mounts or histologic sections)
- There is no treatment. Eliminate infected stocks and disinfect (spores are very resistant and survive for long periods).

## Microsporidia-Pleistophora ovariae

- Infects the liver, kidney and ovary of golden shiners and fathead minnows
- In US may have a prevalence of 46% and dramatically affect the baitfish industry
- The parasite can reduce the spawn and growth of the fish



## Microsporidia-*Heterosporis*

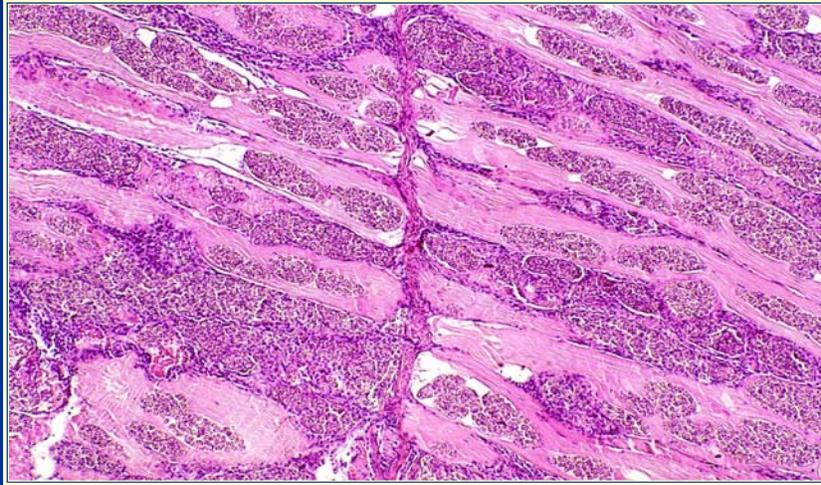
- Recently identified microsporidian of yellow perch, although it has wide host susceptibility



Affected muscle of a yellow perch

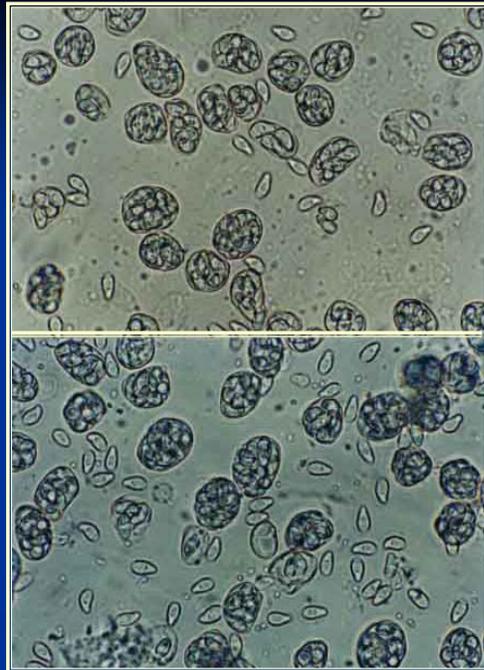


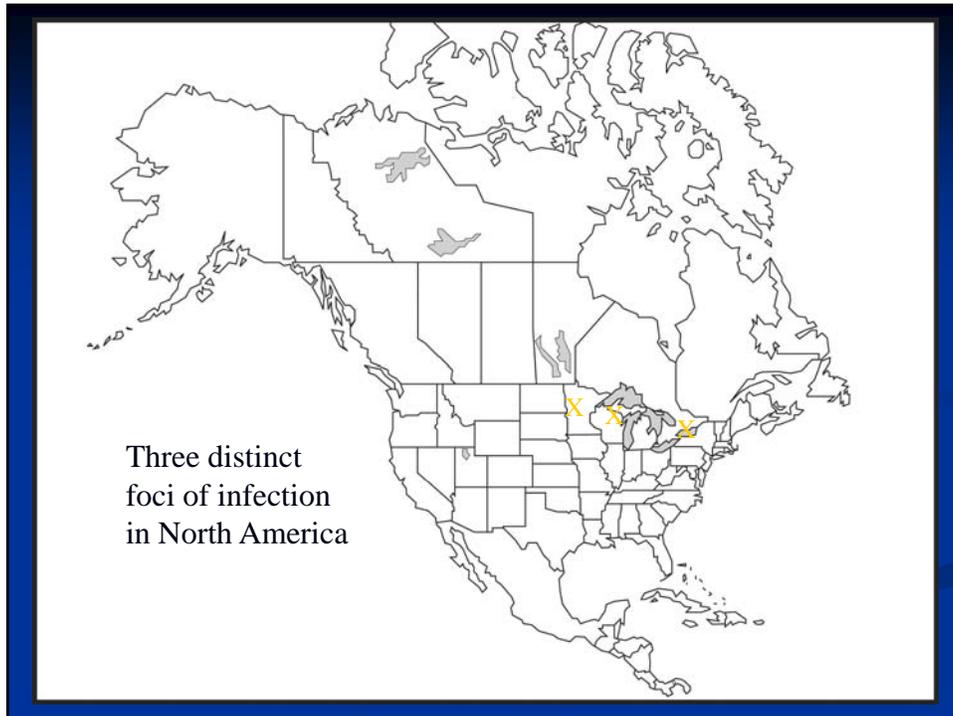
## Heavily infected fillets may be mostly parasite



## Wetmounts

- SPV's contain 8 or 16 spores
- SPV wall fairly resistant to rupturing





### Reports of *Heterosporis* in North America

#### Yellow perch (*Perca flavescens*)

- Chain of Lakes, Vilas Co., WI
- Robinson Lake, Forest Co., WI
- Leech Lake, Cass Co., MN
- Mille Lacs, Isanti Co., MN
- Lake Vermillion, Isanti Co., MN
- Lake Winnibigosh, Isanti Co., MN
- Bear Lake, Itasca Co., MN
- Moose Lake, Itasca Co., MN
- Northern Lake Ontario, Ontario
- Bay of Quinte, Ontario

#### Walleye (*Stizostedion vitreum*)

- Big Sand Lake, Isanti Co., MN
- Chain of Lakes, Vilas Co., WI

#### Northern Pike (*Esox lucius*)

- Clitheral Lake, Ottertail Co., MN

#### Catfish Lake, Vilas Co., WI

#### Mottled sculpin (*Cottus bairdi*)

#### Burbot (*Lota lota*)

#### Pumpkinseed (*Lepomis gibbosus*)

#### Rock Bass (*Ambloplites rupestris*)

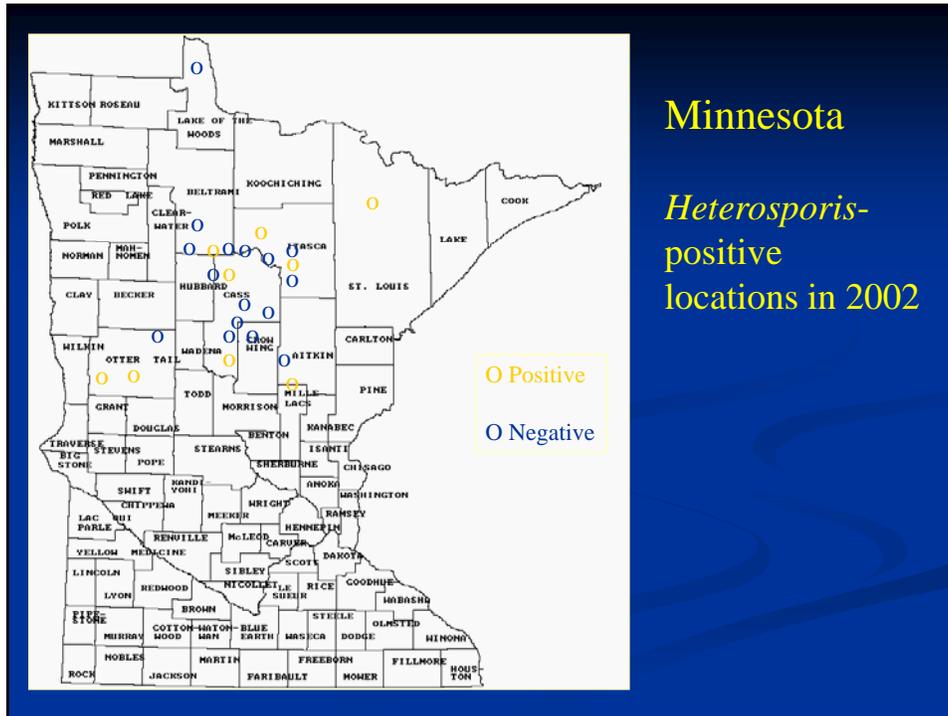
#### Trout Perch (*Percopsis omiscomaycus*)

*Heterosporis*-infected burbot (*Lota lota*)  
from Catfish Lake, Wisconsin



**Vilas County,  
Wisconsin**

**Chain of Lakes:  
Headwaters of  
Wisconsin River**



## Microsporidia-*Glugea*

- Numerous species affected
- *Glugea* can infect multiple organs (attacks connective tissue)
- *Glugea anomala* is the best known species (infects sticklebacks)
- Forms xenomas that appear as white, usually spherical cysts.

