Amphibian Diseases and Pathology

Debra L. Miller, DVM, PhD

Associate Professor/Veterinary Pathologist
Veterinary Diagnostic and Investigational Laboratory
The University of Georgia, College of Veterinary Medicine

Adjunct Associate Professor
Center for Wildlife Health
Department of Forestry, Wildlife and Fisheries
The University of Tennessee, Knoxville

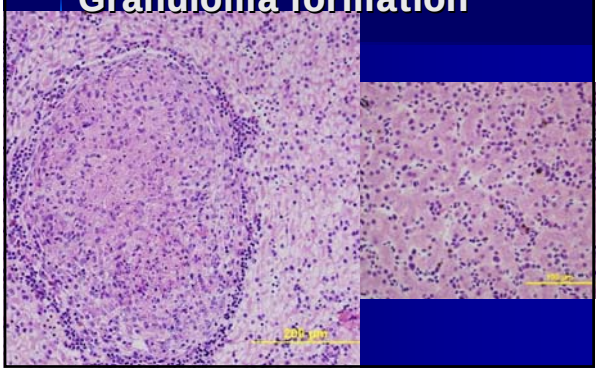
Definitions:

- Pathology = absence from normal.
- Disease = a condition that impairs normal function
- Pathogen = organism that is capable of causing disease (viruses, bacteria, fungi, parasites)
- Not all pathogens cause disease all of the time
- Not all diseases are caused by pathogens (ex: diabetes, most cancers)

PLEASE REALIZE:

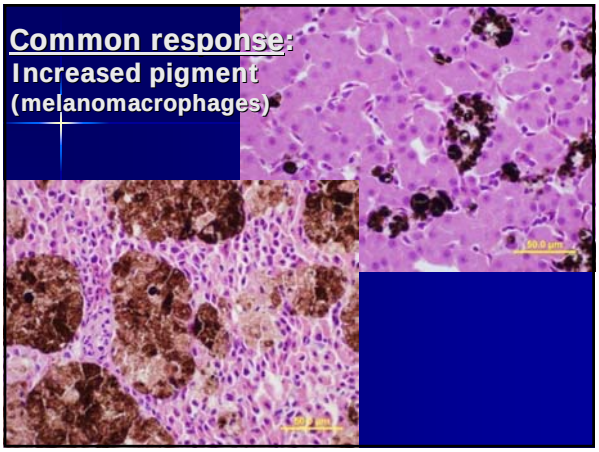
- Symptom is used in HUMAN medicine NOT for animals
  - Things we feel and the patient describes to the physician
- Signs occur in Humans and Animals
  - Things we can measure or observe

Common response = Granuloma formation



Common response:

Increased pigment
(melanomacrophages)



The Basic Pathogens:

- Viruses
- Bacteria
- Fungi
- Parasites (internal & External)

Other Things Causing Pathology:

- Chemicals: Endocrine Disrupters
- UV
- Genetic Mutations

VIRUSES

- Ranavirus
- Frog Erythrocytic Virus
- Lucke Frog Herpesvirus
- Adenovirus
- West Nile Virus

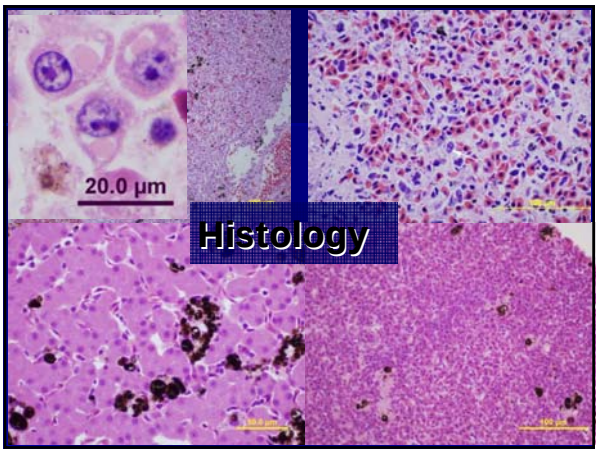
Ranavirus

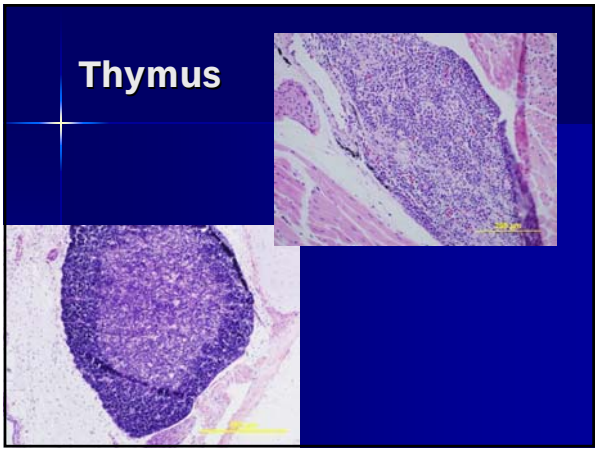
- Frogs/Toads/Salamanders; tadpoles/adults
- Etiologic Agent: Iridovirus
  - Genus: Ranavirus
- Examples:
  - Anurans: Frog Virus 3 (FV3), Tadpole Edema Virus (TEV)
  - Caudates: *Ambystoma tigrinum* Virus (ATV)
- Host: Larvae and Adults but seem most severe in larvae. Unsure about eggs and embryos
- Field Signs: Mass Mortality; Sublethal; Subclinical
- Gross Signs: Skin lesions, Swollen legs and body, red patches on skin (esp at vent), some no lesions (subclinical)

Gross

Gross

Gross





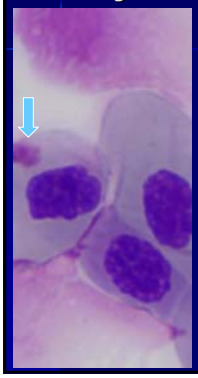
Ranavirus

- Transmission:
  - HORIZONTAL only but still testing for vertical (Duffus *et al* 2008)
- Distribution:
  - Global
- Wildlife Implications:
  - Some species are very sensitive and die, others subclinical
  - Severity seems to be affected by stress
- Public Health: Iridovirus NOT in mammals BUT…if infected amphibians are then prone to opportunistic pathogens, these secondary invaders may be problematic to public health (e.g., E coli, Salmonella, Cryptosporidium)

Frog Erythrocytic Virus

- Frogs; adults and tadpoles
- Synonyms: FEV; intra-erythrocytic virus
- Etiologic Agent: Iridoviridae
  - Tends to be discussed separately but is a *Ranavirus*.
  - Reason separate: It is thought that FEV infects ONLY erythrocytes, whereas other Ranaviruses may infect other cell types.
  - has historically been considered non-pathogenic
  - may just be a general stage of *Ranavirus*.
  - Clearly needs to be explored.
- Host:
  - fish, amphibians, reptiles
  - Adults reported BUT...Tadpoles also observed
- Field Signs: Incidental BUT Deaths reported in severe infections in captivity
- Gross Signs: Anemia; lethargy

Cytology



Frog Erythrocytic Virus

- Transmission: thought to occur via insect transmission (mechanically) but still unclear
- Distribution: Suspect global.
- Wildlife Implications: Unknown

Lucke Frog Herpesvirus

- Frog; egg/tadpole/adult (only prob in adult)
- Synonyms:
  - Lucke tumor herpesvirus
  - Ranid Herpesvirus 1
- Etiologic Agent: Herpesvirus
  - Fish, amphibian and reptile herpes; not certain how related to mammalian or avian herpes (i.e., alpha, beta, gamma).
  - Green sea turtle herpes causing fibropapillomas: novel alphaherpes.
- Host:
  - Appears to be VERY SPECIES SPECIFIC
  - Northern leopard frog (*Rana pipiens*)
  - but may be others we just haven't investigated enough

Lucke Frog Herpesvirus

- Field Signs:
  - None in eggs, embryos or tadpoles. Normal development
  - In adults, none because tumors are in kidneys BUT tumors grow faster in WARMER months
  - HOWEVER, virus is only found in tumors during the colder months (McKinnell, 1973)
- Gross Findings:
  - None in eggs or embryos
  - None in tadpoles (except experimentally)
  - Kidney tumors in adults

Lucke Frog Herpesvirus

- Transmission:
  - Virus is shed from tumors of adults and thus eggs and embryos are infected at spawning.
  - Only see tumors in adults that were infected as embryos/eggs
- Distribution:
  - Range of *Rana pipiens*

Lucke Frog Herpesvirus

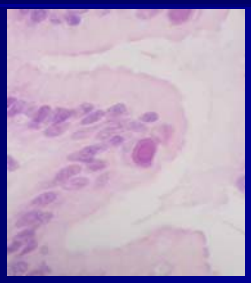
- Wildlife Implications:
  - None known
  - Thus far only reported morbidity and mortality is in adult *Rana pipiens* and it is rare
- Pub Health??:
  - None known but….Frog legs from frogs with kidney tumors are rejected for consumption
- Gee Whiz….
  - This was the first virus that was linked to cancer (tumor formation; McKinnell, 1984).
  - This is the virus scientists were studying when they discovered FV3!

Tweedell 1967

Adenovirus

- Frog but likely salamanders too; Tadpoles but likely adults too.
- Synonyms: Adenovirus Enteritis
- Etiologic Agent: Adenovirus
- Host: Various Amphibian Species
- Field Signs: None reported
- Gross Signs: None or occasionally inflamed intestinal tract in Tadpoles (See inclusions on Histology)

Histology

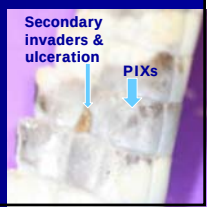


Adenovirus

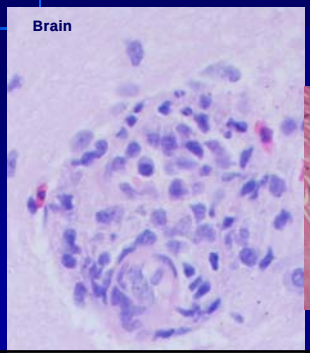
- Transmission: Unknown but presumed fecal/oral
- Distribution: Global
- Wildlife Implications:
  - Generally considered an incidental finding
  - HOWEVER: We are learning more about these and finding that in reptiles they may be serious or cause animals to be more susceptible to other diseases. May be similar in amphibians.
- Public Health: Adenoviruses are not thought to cross taxonomic groups, but unknown

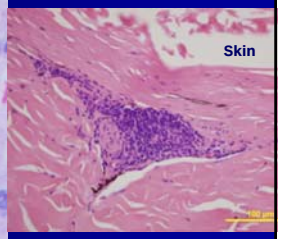
West Nile Virus

- Etiologic Agent: Flavivirus (other similar viruses include: Dengue fever; St. Louis encephalitis virus; Yellow fever virus)
- Host:
  - Have documented experimental infections but low grade
  - not yet documented natural infection in amphibians
  - BUT have documented in reptiles so may eventually document in amphibians
- Field and Gross Signs: in alligators we see neurological signs; Cutaneous lesions (pixs disease); lethargy; death



Histology





West Nile Virus

- Transmission: insect bites; ingestion of infected mosquitos or feces or animals with viable virus
- Distribution: started in eastern Africa but becoming worldwide and the virus is changing
- Wildlife Implications: Mass mortality in naive species but many no real problem. Generally most serious: very young and very old. But not certain what will see in amphibians
- Public Health: Flu-like; Most serious problem (including death): very young and very old

Bacteria:

mostly reported as problem in adults

- Bacterial dermatosepticemia: red leg
- Aeromonas hydrophila
- Salmonellosis
- Mycobacterium ulcerans

Bacterial Dermatosepticemia:

- Synonyms: red leg, bacterial septicemia
- Etiologic Agent:
  - Many agents: most Gram-negative bacilli (rods)
  - Most often attributed to: Aeromonas hydrophila
  - BUT….likely underlying viral (Ranavirus) component
- Host: likely all are susceptible
- Field Signs:
  - random deaths (few to massive)
  - Previously thought was a primary pathogen but now realize that there are likely contributing factors: i.e., wounds from parasites, Ranavirus, etc.
  - Water quality is likely a factor as well

Bacterial Dermatosepticemia:

- Gross Signs:
  - Erythema (reddening) of the skin
  - Cloudy eyes or bleeding in the eye (hyphema)
  - Fibrinous coelitis (body cavity can look like buttered bread)
  - Fibrinous or cloudy lymph sacs
  - Splenomegally (large spleen)
  - Hepatomegally (large liver)

Opportunistic bacteria

Bacterial Dermatosepticemia:

- Transmission: direct but generally through wounds and when immune system is compromised (stress)
- Distribution: global
- Wildlife Implications: Unknown
- Public Health: some of the pathogens may infect humans

Salmonellosis

- Synonyms: Salmonellosis, paratyphoid, food-poisoning
- Etiologic Agent: *Salmonella spp.* Gram-negative bacilli (rods)
- Host: We assume all amphibians may be susceptible and may be carriers
- Field Signs: none reported
- Gross Signs: none reported
- Transmission: fecal-oral
- Distribution: Global
- Wildlife Implications: We assume all serovars are potentially infective but this remains unknown.
- Public Health:
  - potentially infective via handling or via consumption (frog legs).
  - Note: Many species of wildlife may be affected but Salmonella species and serovars affecting amphibians are generally not as contagious to humans (unless compromised)

Mycobacterium

- Etiologic Agent:
  - There are many *Mycobacterium* that are infectious to amphibians (especially *M. marinarum*)
  - Some of the mycobacterium are similar to *Mycobacterium ulcerans* , which is infective to humans and therefore may have zoonotic potential
  - Acid-fast
- Host: various amphibians
- Field Signs: unknown
- Gross Signs:
  - continue to eat but weight loss (may be severe: emaciation), granulomatous inflammation of internal organs
  - Skin lesions
- Transmission: presume direct contact, ingestion
- Distribution: likely global
- Wildlife Implications: unknown
- Public Health: potentially zoonotic

Gross

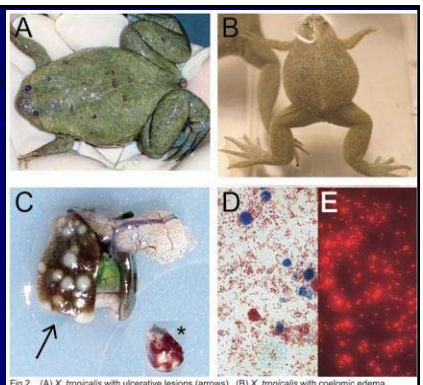


Fig 2. (A) *X. tropicalis* with ulcerative lesions (arrows). (B) *X. tropicalis* with coelomic edema. (C) Internal viscera of *X. tropicalis* illustrating milary granuloma formation on both the liver (arrow) and spleen (asterisk). (D) Photomicrograph of coelomic exudate stained with Ziehl Neelson Acid-Fast stain (red - mycobacteria). (E) Photomicrograph of coelomic exudate stained with Auromine-Rhodamine Fluorescent stain (red- mycobacteria).

http://tropicalis.berkeley.edu/home/husbandry/disease.html

Watermold, Algae, Fungal, Protista:

- Watermold (*Saprolegnia*)
- Algae (*Chlamydomonas*)
- *Batrachochytrium dendrobatidis*
- *Basidiobolus*
- *Protista: Mesomycetozoan*
  - *Ichthyophonus*
  - *Mesomycetozoan-like Infections (DRIPs)*
  - *Dermocystidium and Dermomycoides*

Watermold infection (Saprolegniasis) many types

- **Synonyms: Saprolegniasis**
- **Etiologic Agent:**
  - **primitive fungi (Oomycetes).**
  - **Many genera (Achlya, Aphanomyces, Leptolegnia, Pythiopsis, Saprolegnia).**
  - **Saprophytic freshwater molds...THUS they invade DEAD eggs (aid in decomposition) AND live but damaged eggs and tadpoles and adults (=2nd invader)**
- **Host: egg masses, injured tadpoles and adults (anurans and salamanders)**
- **Field Signs:**
  - **Opaque or fuzzy egg capsules or lesions on tads and adults.**
  - **Common to see <10% infected**
- **Gross Signs: Usually can see but may need hand lens.**
  - **fuzzy or opaque eggs.**
  - **Clumps of cottony white filamentous areas on skin or mouth (common at edges of tail fins, base or tip of the tail, around the vent, tips of digits and mouth**

Gross

Green and Converse 2005

Watermold infection (Saprolegniasis) many types

- Transmission: opportunistic through injuries or otherwise compromised surfaces. Exposure is likely continuous.
- Distribution: Global
- Wildlife Implications: Unknown for eggs but may infect amphibians and fish egg masses. Thought to be minimal in larvae and adults.
- Public Health: none known

Algae (*Chlamydomonas sp*)

- Etiologic Agent: *Chlamydomonas sp*
- Host: Only reported as 'problem' in EGGS
  - spotted salamnader (*Ambystoma maculatum*)
  - northwestern salamander (A. *gracile*)
  - Possibly other species but not reported
- Field Signs: egg masses are translucent or greenish (because of algae chlorophyll)
- Gross Signs: eggs and embryos are greenish (because of algae chlorophyll). But DEVELOP NORMALLY
- Transmission: direct
- Distribution: unknown but the pathology likely depends on host distribution
- Wildlife Implications: Appears to be a SYMBIOTIC relationship.
- Public Health: None

Batrachochytrium dendrobatidis

- Synonyms: Chytrid, Chytridiomycosis, Bd
- Etiologic Agent:
  - *Batrachochytrium dendrobatidis*
  - There are many chytrids (saprophytic fungi) but only Bd is pathogenic to amphibians
  - Bd only infects cells that contain keratin (keratinized skin cells)
- Host:
  - Suspect any adult amphibian
  - tadpoles (only oral disc because of keratin)

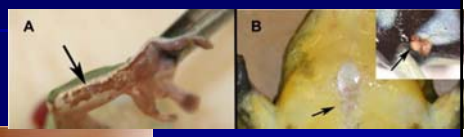
Batrachochytrium dendrobatidis

- Field Signs:
  - Tadpoles: thought to behave and grow normally but die when metamorph because of keratinized skin
  - Adult anurans: considered insidious with persistent gradual deaths more often than mass mortality. Varies by species
  - Adult salamanders: no mass mortality reports but suspect population declines in Central America

Batrachochytrium dendrobatidis

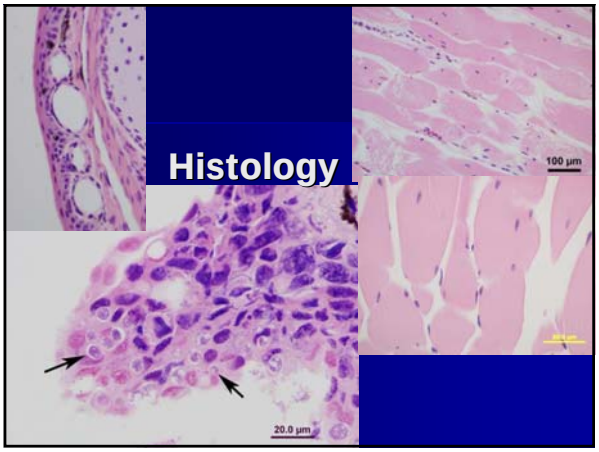
- Gross Signs:
  - Tadpole:
    - jaw sheaths and 'tooth' rows of the oral disc.
    - ALSO toe-tips of late stage tadpoles (Gosner 42-45)
    - Loss of melanin (black pigment), rounding of the cutting edges of the jaw sheaths, sloughing of the pigmented portion of the 'teeth' with preservation of the tooth ridges.
  - Adults
    - Lethargy, weakness, poor righting reflex, fearlessness, abnormal posture, dehydration, death
    - Often only mild thickening of skin is noted (presents as abnormal molting)
    - Some have reddening (erythema) of the skin of the ventrum, especially at pelvic patch, ventral thighs, ventral calves and toes.
    - Thought is that dehydration is due to inability to absorb water through skin. Also theorized to interfere with Na pump of cells

Gross



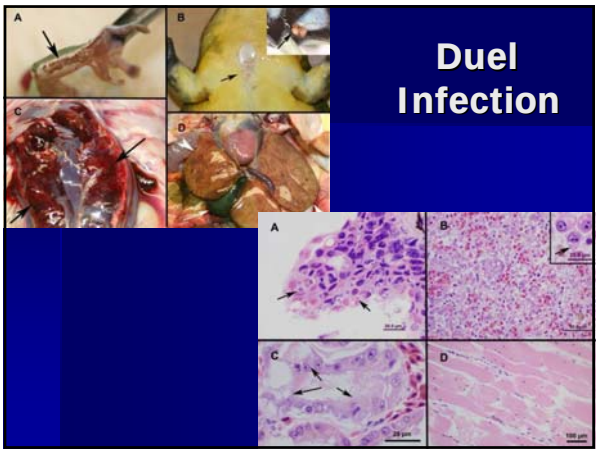
http://amphibiaweb.org/chytrid/index.html

Histology



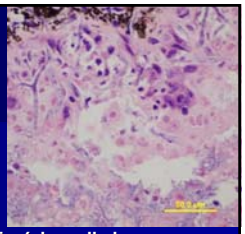
Batrachochytrium dendrobatidis

- Transmission:
  - The zoospore is the infective stage and is motile, thus may be infective via surface water.
  - Unknown how long zoospores can survive in environment
  - Also infective by direct contact (incl. breeding)
- Distribution: Becoming Global
- Wildlife Implications
  - Tadpoles: Not really known because although it is considered innocuous in larvae, infected tadpoles may die at metamorphosis
  - Adult anurans: Grave for many species. Especially rapid and severe population declines for toads and some ranids
  - Adult salamanders: unknown but may be contributing factor to decline of flatwoods salamander and southern dusky salamander (because declines have been reported post-chytrid infected anuran reports)
  - OTHERS: predators that rely on amphibians will likely be affected at the population level, as well
- Public Health: none



Duel Infection

Basidiobolus



- **Synonyms:** Basidiobolomycosis; (also called: Zygomycosis but mainly by veterinarians)
- Etiologic Agent: Basidiobolus. Commensal. Not thought to be pathogenic. Often find in cases of BD and are erroneously implicated as the cause (Realize: for Basidiobolus we see hyphae and BD we see spores)
- Host: variety of amphibians
- Field Signs: none. Common in healthy animals (skin, feces/cloaca, intestines)
- Wildlife Implications: unknown
- Public Health: rare but occasional human infections

Protista: *Mesomycetozoan*

- *Ichthyophonus*
- *Mesomycetozoan-like Infections (DRIPs)*
- *Dermocystidium and Dermomycoides*

Ichthyophonus

- **Synonyms:** Ichthyophoniasis, ***Histocystidium ranae***
  - Misidentified as: Ichthyosporidium and adiaspiromycosis
- **Etiologic Agent: Ichthyophonus**
  - Now in clade: Mesomycetozoa (same as *Psorospermium* of crayfish and *Rhinosporidium* of horses and humans)
- **Host: larval and adult amphibians (also see in fish).**
  - Most often reported: Bullfrogs, green frogs, eastern red-spotted newts (*Notophthalmus viridescens*)

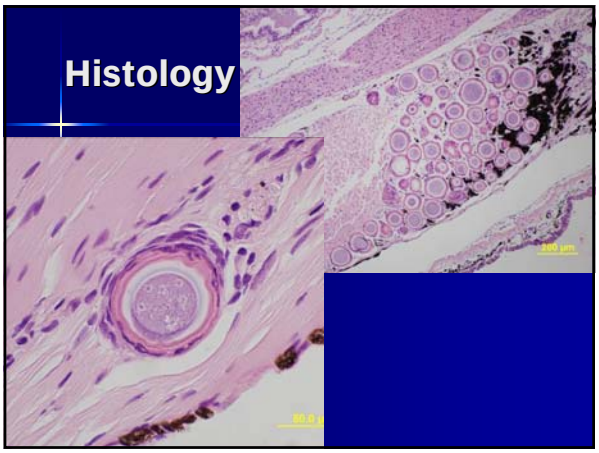
Ichthyophonus

- **Field Signs: Four forms of disease:**
  - 1. inapparent infections
  - 2. swelling of the rump around the urostyle (tail bone) of recent metamorphs (esp. bulls and greens)
  - 3. swellings of the lower body (axial muscles, rump, tail and proximal hind limbs in eastern red-spotted newts
  - 4. rare: emaciation, severe lethargy & death in adults (Ranids & newts)
- **Gross Signs: see swollen skeletal muscle.**
  - In larvae... tail muscle, inguinal muscles and subjacent to gular area.
  - In adults, usually is evenly disseminated throughout muscles of body

Gross

Green and Converse 2005

Histology



Ichthyophonus

- Transmission: Unknown
- Distribution:
  - Primarily reported along eastern US and also in Quebec
  - In TN: reports include spotted salamanders
  - Fresh water and marine
- Wildlife Implications:
  - Really unknown but may have population impacts if severe
  - Highest prevalence is thought to be in adult red-spotted newts
  - Unknown if same species affects salamanders and anurans
- Public Health: none but realize a member of this clade can infect humans

Mesomycetozoan-like infections (DRIPs)

- Synonyms: DRIPs, Dermosporidiosis
- Etiologic Agent: *Dermosporidium penneri*
- Host:
  - Only found in adult toads in the US and only during breeding.
  - *Bufo americanus*.
  - Possibly also in Fowler's toad (*B.woodhousii fowleri*) and Yosemite toad (*B. canorus*)
- Field Signs:
  - Prevalence: 5-15%
  - Mortalities not reported, even in severe cases
- Gross Signs:
  - One to numerous cyst-like structured filled with spores.
  - Ventrum around vent but occasionally other areas

Gross

Green and Converse 2005

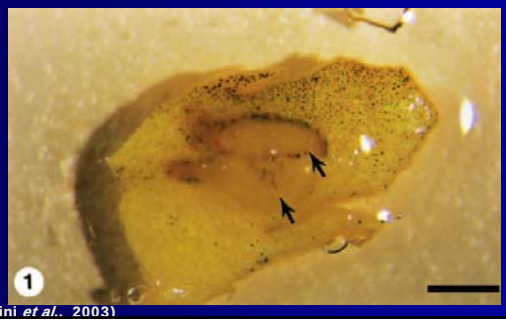
Mesomycetozoan-like infections (DRIPs)

- Transmission: unknown but the spores from the skin pustules are thought to be the infective stage. Thus rupture often occurs during breeding and toads may become infected while in water or eating prey from infected water.
- Distribution:
  - only reported in US and mostly along coastal northeastern US (other = CA-Yosemite)
  - but similar to what see in Europe from similar organisms
- Wildlife Implications: seems to only affect toads in US but in Europe the similar disease affects frogs and toads
- Public Health: none

Dermocystidium and Dermomycoides

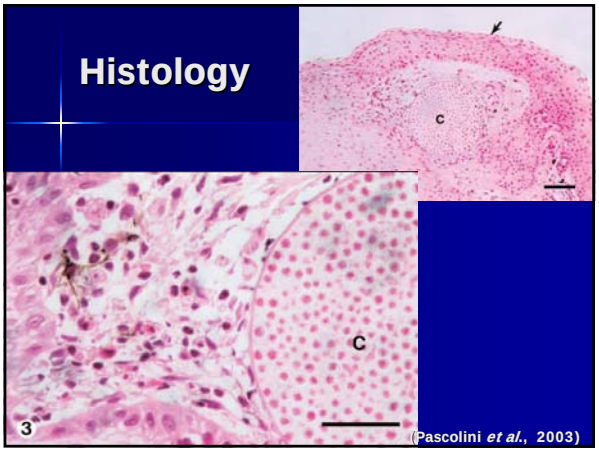
- NOTE: In Europe this is causative agent of DRIPs
- Etiologic Agent:
  - suspect is also a member of the clade *Mesomycetozoa* (i.e., as *Dermosporidium penneri*)
  - Pascolin, et al. (2003) suggest that they be placed in a new genus *Amphibiocystidium* (and *Dermocystidium* only used for fish)
- Host: European anurans
- Field Signs: similar to DRIPs in North America
- Gross Signs: similar to dermosporidiosis (DRIPs) in North American anurans
- Transmission: likely similar to Dermosporidium
- Distribution: Europe
- Wildlife Implications
- Public Health

Gross from *Rana esculenta*



(Pascolini *et al.*, 2003)

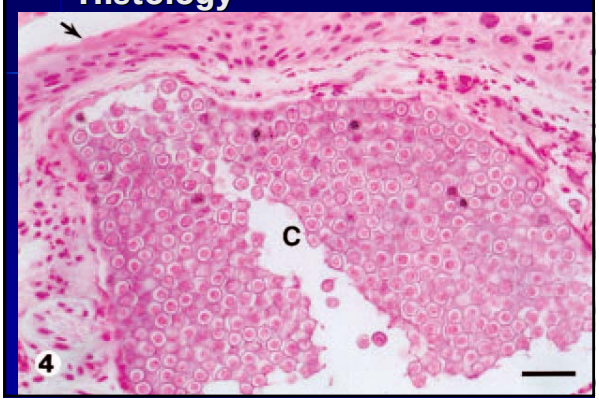
Histology



(Pascolini *et al.*, 2003)

(Pascolini *et al.*, 2003)

Histology



Parasites

- Protozoans
- Metazoans/Helminths
- Ectoparasites

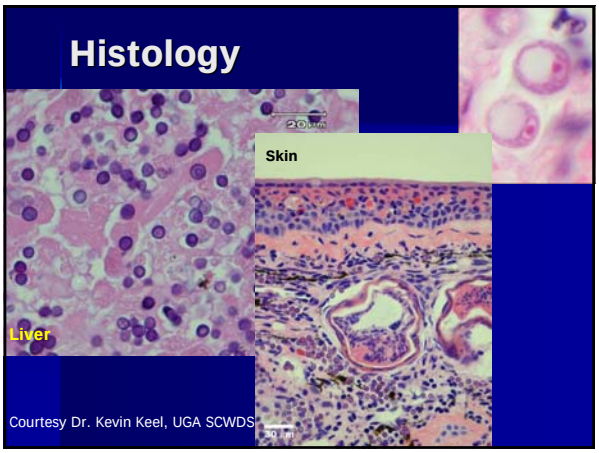
Protozoal:

- Perkinsus-like: Alveolate
- Microsporidia
- Myxospiridia
- Coccidia
- Others that we see:
  - Amoeba
  - Ciliated protozoa
  - Flagellated protozoa (Trypanosomes)

Perkinsus-like: Alveolate

- **Etiologic Agent: Recently classified as an Alveolate (Davis *et al.* 2007).**
- **Host: anurans (so far)**
- **Field Signs: mass mortalities**
- **Gross Signs:**
  - **Skin lesions. Sloughing.** Proteolytic degradation of tissue (melts the tissue away).
  - BUT: See organisms on histological examination and in multiple organs.

Histology



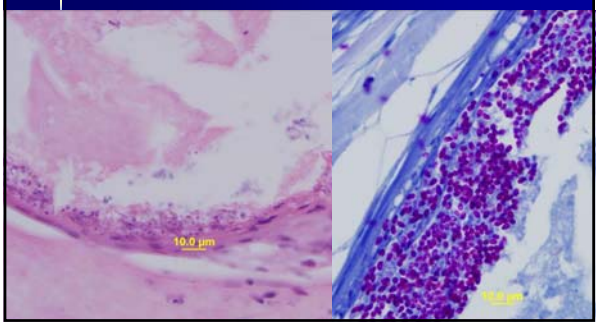
Perkinsus-like: Alveolate

- **Transmission: presumed direct contact**
- **Distribution:** So far: Alaska, Georgia, Ohio, Mississippi, Australia
- **Wildlife Implications: Mass mortalities of local populations**
- **Public Health: unknown**
- **We still know very little because there have been few reports in the US, thus far**

Microsporidia

- **Synonyms: Microsporidiosis, protozoonosis**
- **Etiologic Agent: *Microsporidium schuetzi***
- **Host: only reported as problem in Northern leopard frog eggs**
- **Field Signs: egg mass appears enlarged, pale brown to whitish gray, loss of distinct polar pigmentation. Only affects small portion of mass**
- **Gross Signs: enlarged (50-100%) eggs and homogeneous in color**
- **Distribution: report in Vermont but organism is widely distributed**
- **Wildlife Implications: suspect contribute to population declines**
- **Public Health: None**

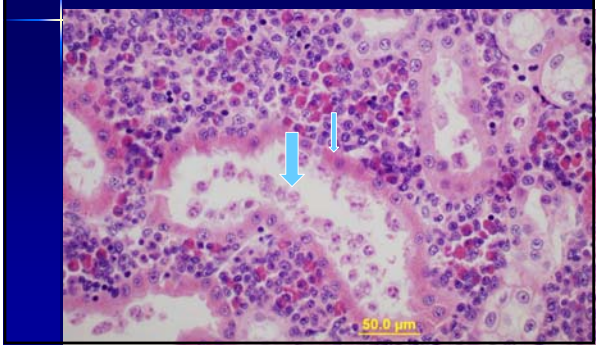
Histology (fish in SE US)



Myxosporidia

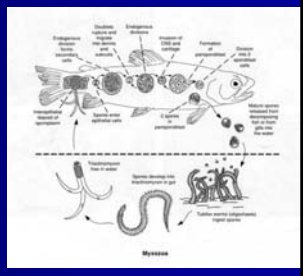
- Etiologic Agents and hosts:
  - *Leptotheca ohlmacheri*: tadpoles and adult anurans
  - *Myxidium spp* and *Chloromyxum spp*: bile ducts and gall bladders of anurans and salamanders
  - *Myxobolus spp*: gonads of Old World and Australian amphibians
- Field Signs
- Gross Signs: None. Depending on species, will see in renal tubules or bile ducts and gall bladder on histological examination

Histology



Myxosporidia

- Transmission:
  - unknown
- Distribution:
  - possibly global
- Wildlife Implications:
  - Possibly if Heavy infection
- Public Health:
  - None



Gardiner *et al.*, 1998

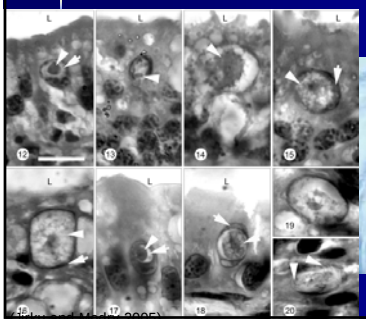
Coccidia

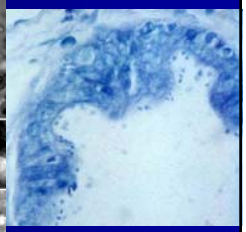
- Etiologic Agent: *Isospora* and *Eimeria* suspect *Cryptosporidium* as well
- Host: likely tadpoles and adults (including in caecilians)
- Field Signs: None reported
- Gross Signs: likely none unless severely infected or compromised, then perhaps diarrhea. Generally see on fecal examination or histological examination
- Transmission: direct (fecal/oral)
- Distribution: likely global
- Wildlife Implications: Unknown
- Public Health: unknown but generally these are somewhat host specific. HOWEVER...amphibians may possibly be transport host

Fecal

Histology:

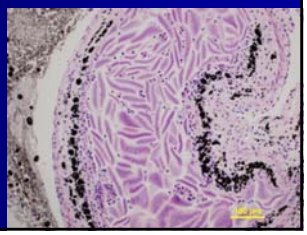
Eimeria in various African anurans
Crypto in corn snake (*Elaphe guttata guttata*)





Others that we see

- Amoeba
- Ciliated protozoa
- Trypanosomes



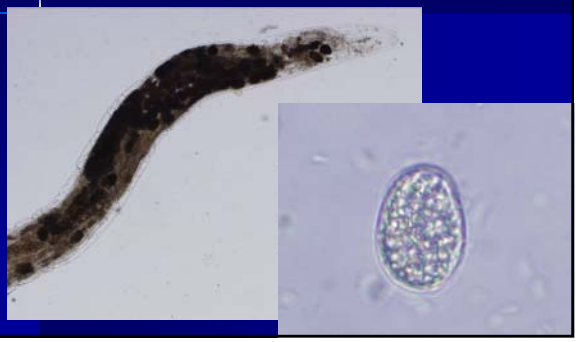
Metazoans (Helminths)

- Nematodes
- Cestodes
- Trematodes

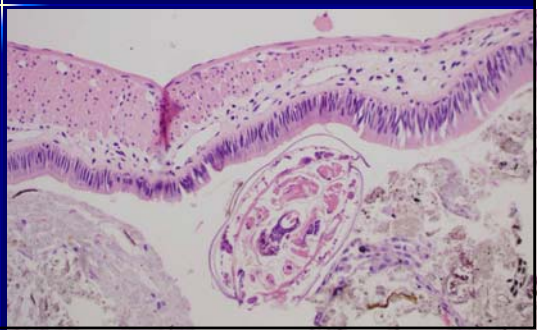
Nematodes

- Synonyms: roundworms
- Etiologic Agents and hosts: various but
  - Rhabdias spp: lungworm. Penetrate skin and migrate to lungs. Little damage noted UNLESS heavy infection
  - Strongyloides spp (direct life cycle): intestinal
  - Fiolarid nematodes (direct): free in coelomic cavity and microfilaria in blood
  - *Pseudocapillaroides xenopi*: cutaneous (skin) hemorrhage and exfoliation in *Xenopus laevis*
- Field Signs: usually only a problem if heavy infections or compromised hosts
- Gross Signs: some skin lesions, see parasites on necropsy or see parasite eggs on cytology of fecal sample (*Strongiloides*)

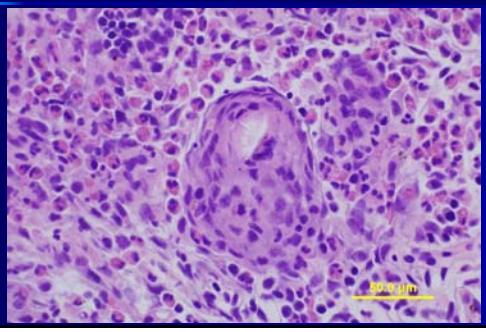
Cytology of Fecal Sample



Histology: Intestinal



Histology: Lung



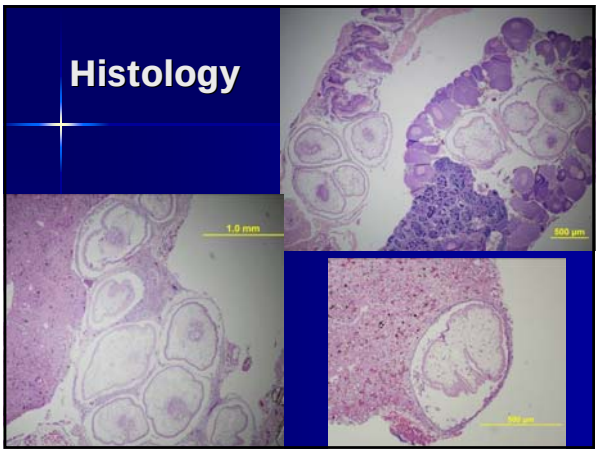
Nematodes

- Transmission: most direct
- Distribution: Probably Global
- Wildlife Implications: Probably only if heavy infection or if compromised populations
- Public Health: Probably none as most are fairly species specific

Cestodes

- Synonyms: Tapeworms
- Etiologic Agents and hosts: various
- Field Signs: usually only a problem if heavy infections or compromised hosts
- Gross Signs: Usually only see on histology BUT if severe infection, may be thin or emaciated.
- Transmission: not clear, may be direct or indirect
- Distribution: likely global
- Wildlife Implications: Probably only if heavy infection or if compromised populations
- Public Health: Probably none

Histology



Trematodes

- Ribeiroia
- Clinostomum

Ribeiroia

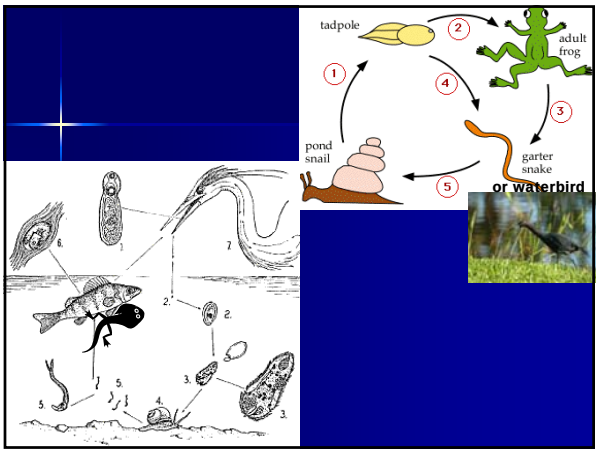
- Synonyms: Formerly called: *Psilostomum ondatrae*
- Etiologic Agent:
  - Many species but generally *Ribeiroia ondatrae*
  - Cercaria penetrates the larval skin and then encysts as a metacercariae.
- Host:
  - First intermediate: snails
  - Second intermediat: fish/amphibians
  - Final: waterbirds and snakes

Ribeiroia

- Field Signs:
  - Malformations.
  - Generally malformation rates 3-50% are considered due to *Ribeiroia*
  - But severe ones we likely don't see because they die. No known record of those
  - Experimentally: mortalities with as few as 5 metacercariae
- Gross Signs:
  - Malformation of various types BUT usually supernumerary.
  - LOCATION of cysts is Key to problem

Clinostomum

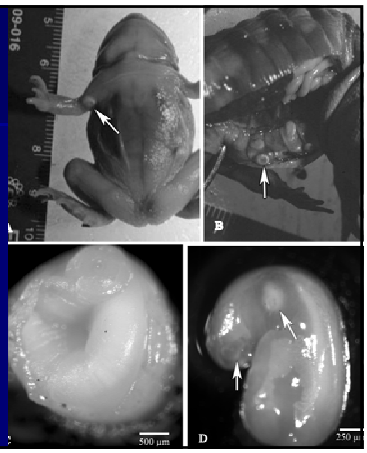
- Synonyms: Yellow Grub (fish)
- Etiologic Agent: Metacercariae of the digenean (complex life cycle; at least 2 hosts to complete) trematode (fluke)
- Host:
  - First intermediate: snails
  - Second intermediat: fish/amphibians
  - Final: waterbirds and snakes



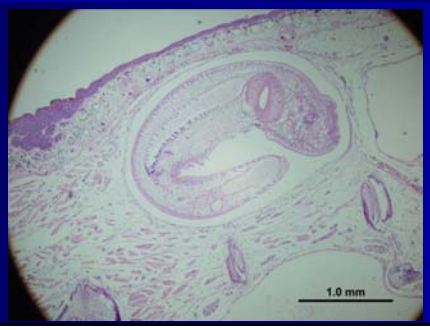
Clinostomum

- Field Signs: Can be easily seen as 'nodules' on skin. Unsure if could potentially result in malformation
- Gross Signs:
  - Raised 'nodule' on skin (2-3mm)
  - Occasionally see internally, especially in salamanders

Gross



Histology:



Clinostomum

- Transmission: as noted in life cycle, free-swimming cercariae invade skin
- Distribution:
  - Unknown but thought to be at least nationwide
- Wildlife Implications:
  - Minimal but may be a problem depending on location and developmental stage of the amphibian
  - Can be individual problem. Salamanders may be more affected.
  - Devastating to catfish.
- Public Health: Some species of Clinostomum may infect mammals (incl humans) in Asia. BUT proper cooking kills the metacercariae in frog legs and fish.

Ectoparasites

- Leeches
- Anchorworms
- Mites

Leeches

- **Synonyms:** none
- **Etiologic Agent:**
  - Genera: *Placobdella*, *Macrobdella*, *Batracobdella* and *Oligobdella*
  - They are really opportunistic
- **Host:**
  - Larval and Adult amphibians
  - Ranids are most often reported
- **Field Signs:**
  - Blood loss anemia
  - Secondary transmission of protozoans
  - Possible secondary transmission of bacteria, watermolds and viruses
  - Malformations by *Erpobdella octoculata* in the European toad (*Bufo bufo*) in Germany

http://tripod.com/naturebox/aquatica/jjleechfrog.html

Leeches

- Gross Signs:
  - circular bite wounds
  - Small amphibians...may have ½ blood loss
- Distribution: US and Canada
- Wildlife Implications:
  - Weakness due to blood loss anemia
  - Transmission of secondary invaders
  - Wounds
  - malformations
- Public Health: Unknown

Anchorworms

- Etiologic Agent:
  - *Lernaeea cyprinacea.* ONLY THE FEMALES ARE PARASITIC
  - Anchorworms=copepods (class Crustacea/phylum Arthropoda)
- Host:
  - Mostly fish
  - Larval anurans (bulls & greens) & occasionally post-metas
- Field Signs:
  - Prevalence not reported (assume sporadic deaths).
  - Usually find in waters with fish
- Gross Signs:
  - head penetrates deep in soft tissue [only reproductive organs remain visible (bilaterally symmetrical pair of ovoid to elongate egg sacs)]
  - In tadpoles, usually see near oral disc and base of tail

Green and Converse 2005

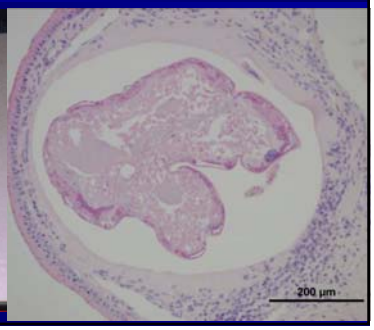
Anchorworms

- Distribution: Unknown (reports include Ohio and Georgia)
- Wildlife Implications:
  - Uncertain
  - Likely individual:
    - mortalities in tadpoles directly or from secondary invasion
- Public Health: None

Mites

- Synonyms: Chiggers
- Etiologic Agent: Usually genus: *Hannemania.*
- Field Signs: Only see gross specs in skin
- Gross Signs: small (<1mm) firm specs in skin. Red or white
- Transmission:
  - Although mites have 4 life stages (eggs, larvae, nymphs, adults) only the larvae infect amphibians.
  - Mite larvae are directly invasive when hatch.
- Distribution: most reported in southern U.S. and mostly late summer, autumn, winter and early spring (larvae remain in host for 6-9 months and leave in summer).
- Wildlife Implications: none known
- Public Health: none as this is a different genus than what infest humans.

Mites



Mutations?:

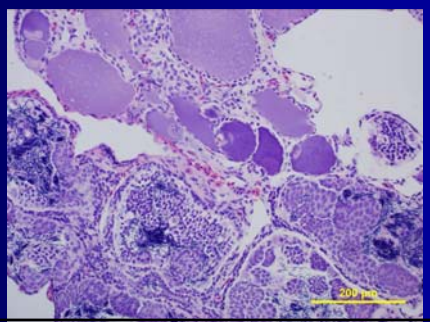
- White Egg Mutation: Pale egg and Albinism (recessive trait)
- Black pigment of eggs comes from the female (maternal pigment) and persists until a few days before hatching. Then embryos produce their own pigment UNLESS they inherited recessive genes, then may be albino
- But realize that other pigments may then be present

Others

- Chemicals: Endocrine Disrupters
- UV
- Genetic Mutations

Endocrine Disrupters:

Ex. Atrazine but possibly others such as growth hormones



Unknown (wastewater):
Calcium but unclear why or how

Courtesy Dr. Kevin Keel, UGA SCWDS

QUESTIONS?