NC STATE UNIVERSITY

AHD2: VET 921
Parasitology Section

Digenetic Trematodes
Flukes

Flukes in General

Take Homes

- Trematodes are Flukes
- Understand the basic anatomy of an adult flukes.
  - Unsegmented body, general flatworm characteristics
  - Often with suckers for holdfasts organs
  - Monoecious – both male & female repro organs in one body. (except blood flukes – see later)
  - Incomplete gut
  - No digestive system, absorbs food across tegument
- Understand the basic lifecycle of most flukes.
  - Adult Fluke in Definitive Host. Various organs depending on fluke species.
  - Always has a snail host (aquatic or terrestrial) [1st IH], in which asexual reproduction makes a lot of larval stages.
  - Larvae from snail encysts in another host or on vegetation. [2nd IH]
  - DH is infected when it ingests the 2nd IH that is infected with the larval fluke.
- Geographic range of snail-host species restricts geographic range of fluke species.
- Praziquantel is the preferred dewormer against flukes and tapeworms.

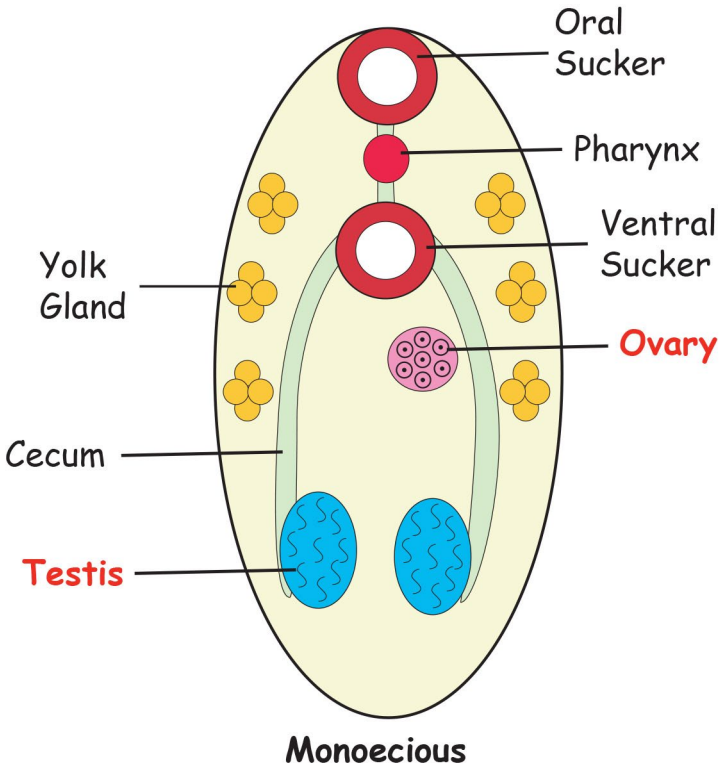
Digenetic Trematodes

Digenea (di = two), (genea = beginnings)

a. Sexual Reproduction => Adult worms in definitive host
b. Asexual Reproduction => Larval worms in snail host

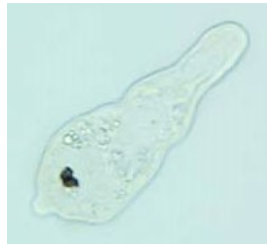
Morphology

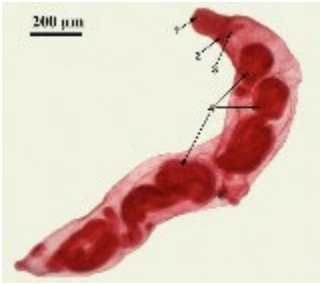
1. General Flatworm Characteristics
2. Suckers and/or holdfast organs
3. Incomplete gut
4. Reproductive organs
   (testes, ovary, vitellaria)



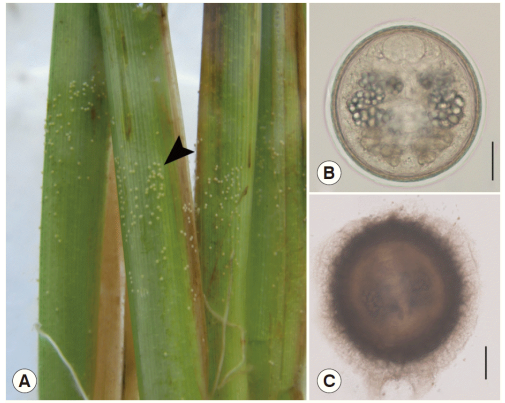
Digenetic Trematodes

Complex Life Cycle





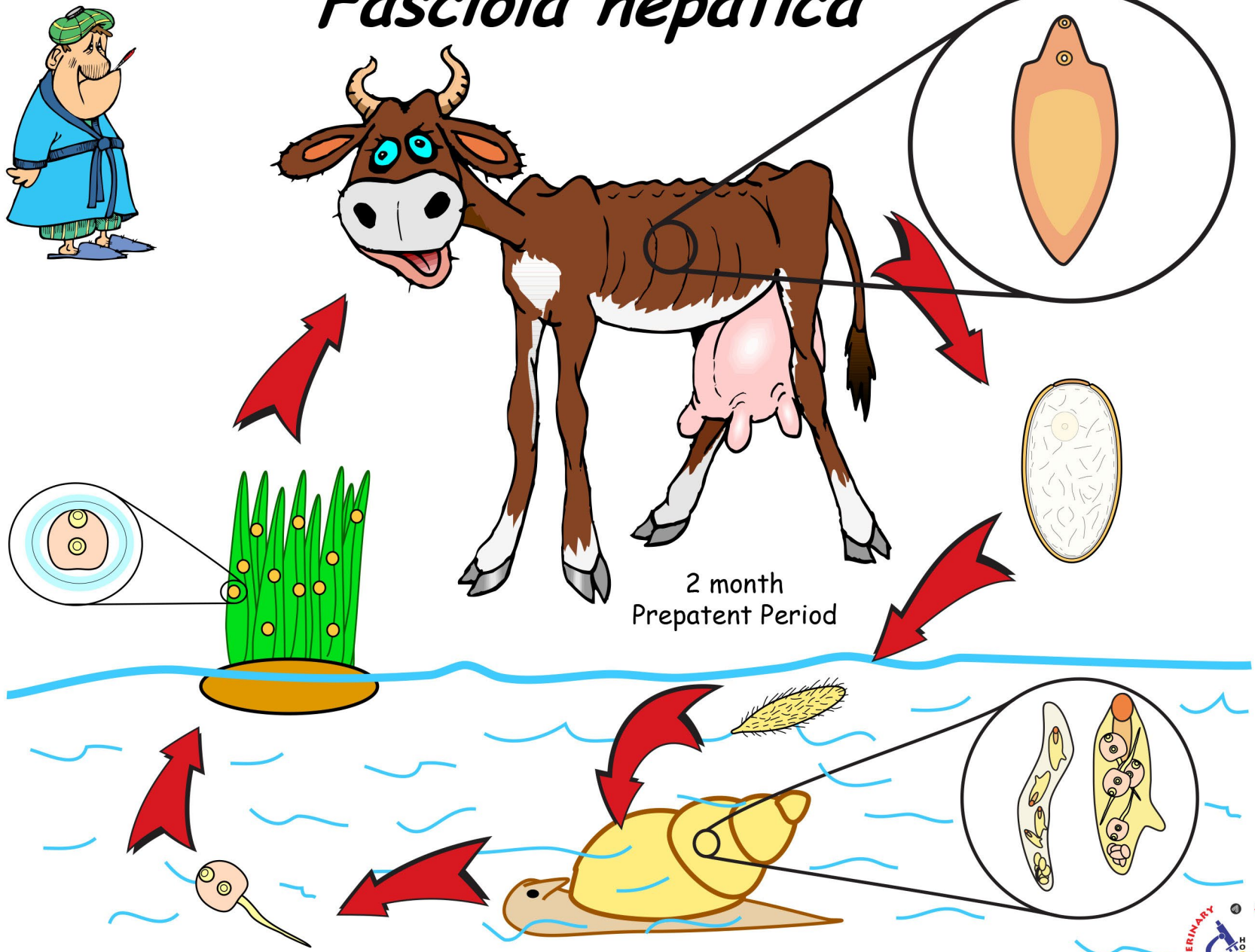
1. Definitive Host
    a. Adult Worms (Sexual Reproduction)
2. Environment
    a. Ovum (Distribution)
    b. Miracidium (Distribution)
3. **Snail** 1st Intermediate Host
    a. Sporocysts and/or Rediae (Asexual Reproduction)
4. Environment
    a. Cercaria (Distribution)
5. 2nd Intermediate Host or Environment
    a. Metacercaria (Transmission)



Client Education

A cattleman is very concerned that he has lost much profit because of the condemnation of his cattle's livers. He was told by the abattoir meat inspector that many of his steers had "flukey livers". It is determined that the fluke is *Fasciola hepatica*. Using the *Fasciola hepatica* life cycle illustrated in the next slide, explain the life cycle, **as you would to your client**.

Fasciola hepatica



Digenean Groups

In general, flukes are grouped by their habitat within the definitive host.

Large Animals

Liver Flukes

Fasciola (ruminants)
Fascioloides (ruminants)
Dicrocoelium (ruminants)

Intestinal Fluke

Acanthatrium (bat/horse)

Small Animals

Liver Fluke & Pancreatic Fluke

Platynosomum (cats) FYI
Eurytrema (cats) FYI

Lung Fluke

Paragonimus (dogs, cats)

Intestinal Fluke

Nanophyetus (dogs)

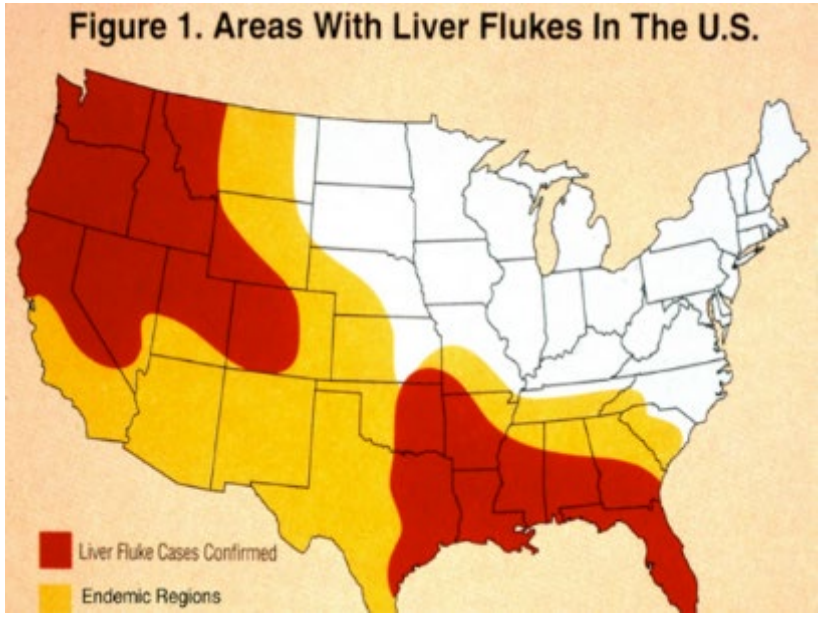
Blood Fluke

Heterobilharzia (dogs)

Trematodes = Zebras

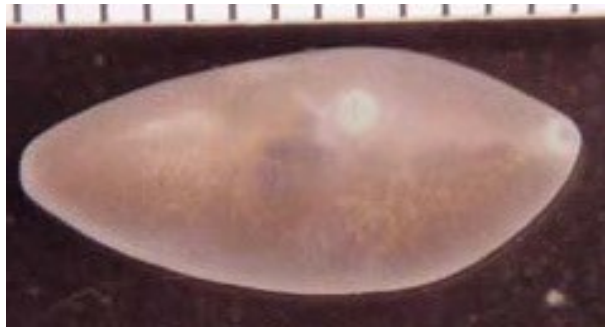
Most of the time

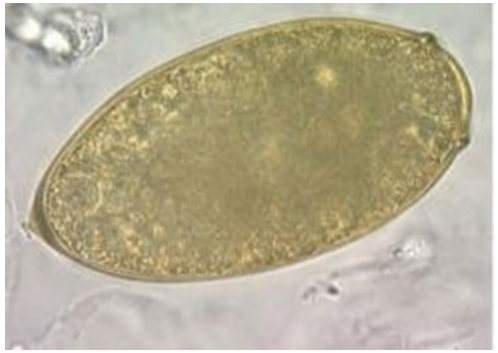
- Geography plays an important role in fluke diagnostics.
- Fluke endemicity is tied to the geographic range of their snail hosts.

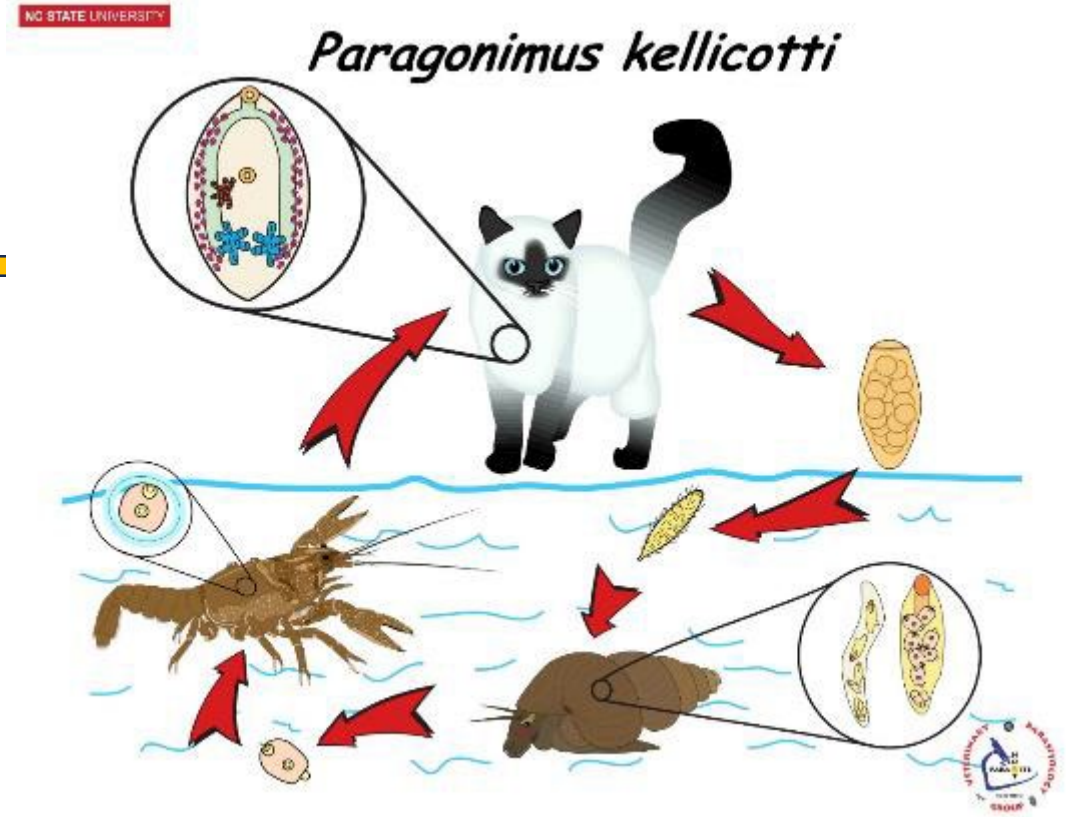


- **When beginning practice in a new area, consult with experienced vets and/or extension agents to be aware of endemic fluke diseases.**

Paragonimus kellicotti
Lung Fluke of Pets







Life Cycle HIGHLIGHTS

- Aquatic
- Definitive Hosts -- Dogs & Cats (Pigs, Raccoon, Mink, etc.)
  - Lung Parenchyma
- River snails
- 2nd Intermediate Host -- Crayfish

Geographic Distribution

- Throughout North America
- Cases in North Carolina (dogs, cats, mink, raccoons, bobcats)

Zoonosis

- *Paragonimus kellicotti*
  - Wildlife lung fluke in North America
  - Zoonosis has been reported.
    - Human infection from eating raw or undercooked crayfish
- *Paragonimus westermani*
  - human lung fluke in orient

The Liver Flukes

Fasciola hepatica
Fascioloides magna
Dicrocoelium dendriticum

Liver Flukes

Take Homes

Fasciola hepatica

- Geographic range: Gulf Coast, Florida, Pacific Northwest. But check transport history
- DH: Ruminants, bile ducts. Snail Host: Aquatic puddle/pond snail. 2nd IH: vegetation
- Pathology:
  - Young flukes in liver parenchyma – cause acute hepatitis possibly death
  - Adult flukes in bile ducts – bile duct stenosis, hepatitis, anemia, hypoproteinemia & bottle jaw
  - Liver condemnation = economic loss
  - DZ may mimic Haemonchosis in small ruminants or Ostertagiasis in cattle
  - May cause Black Liver DZ or Red Water DZ due to associated Clostridial infections
- Diagnosis: Sedimentation, necropsy
- Control: No access to wet pastures / ponds, etc. Zoonotic: yes

Fascioloides magna

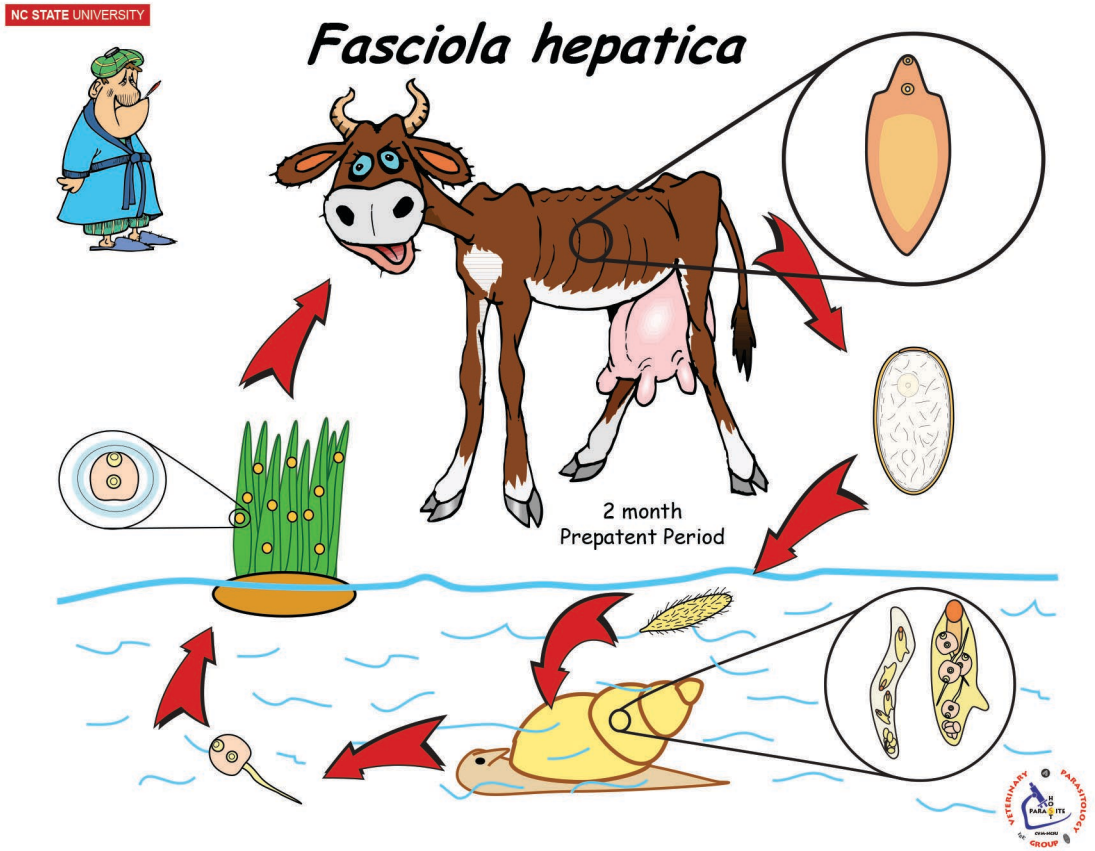
- Geographic range : Sporadic in US including NC
- DH: Deer - liver cavities. (diagnose w/ sedimentation) Snail Host: Aquatic puddle/pond snail. 2nd IH: vegetation
- Dead-end Hosts:
  - Cattle – walled off liver pockets → liver condemnation (diagnose @ necropsy);
  - Sheep & goats – migrating young flukes cause acute hepatitis and death (diagnose @ necropsy)
- Control: No access to wet pastures / ponds, etc., No deer access. Zoonotic: no

Dicrocoelium dendriticum

- Geographic range: Northeastern US (NY, PA, etc.)
- DH: Sheep & goats (minor issue for cattle) (diagnose w/ sedimentation)
- Snail Host: Terrestrial snail. 2nd IH: ants (accidentally ingested while grazing)
- Pathology:
  - Young hosts: minor DZ;
  - Older hosts: bile duct stenosis, liver dysfunction w/ decreased productivity.
- Control: No ants. Zoonotic: Yes

Fasciola hepatica

Common Liver Fluke



Life Cycle HIGHLIGHTS

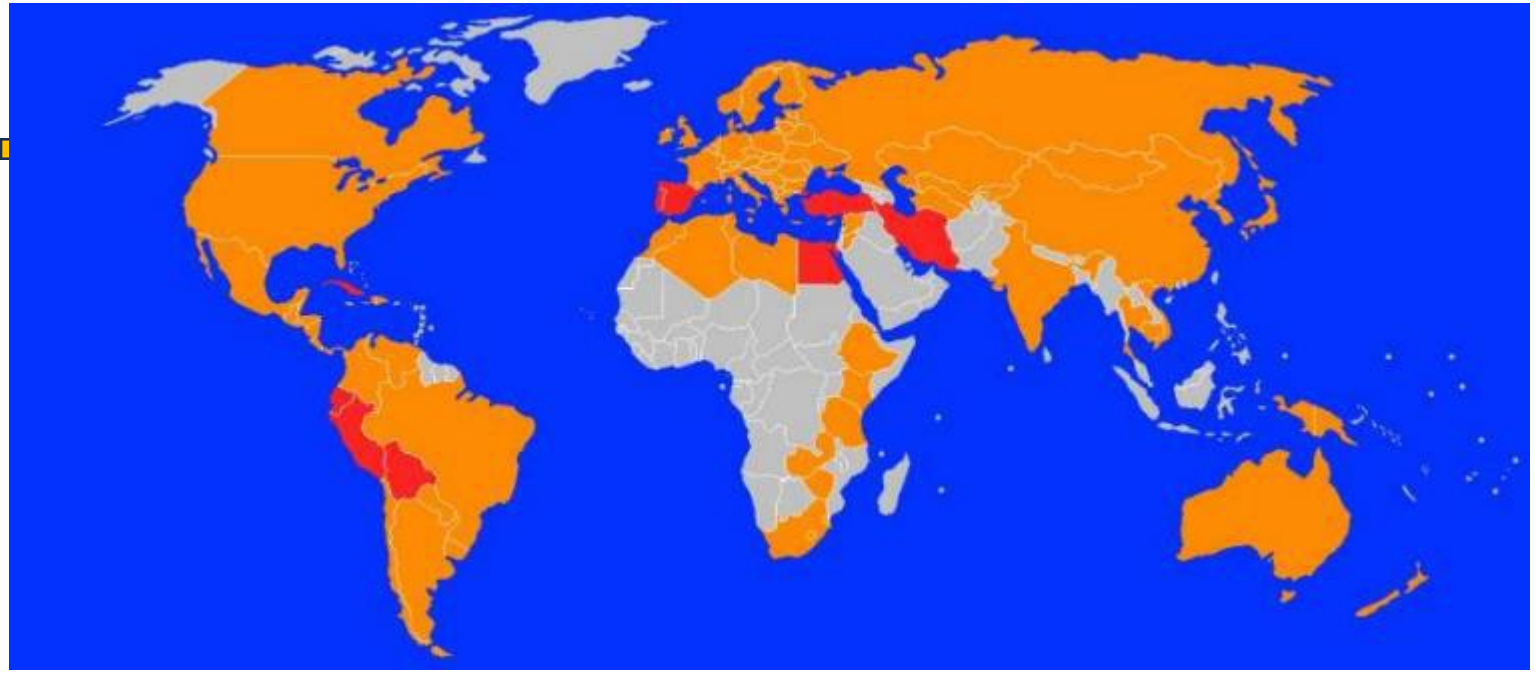
- Aquatic
- Definitive Hosts -- Cattle, Sheep, Goats & Camelids
  - Liver & Bile Ducts
- Pond / Puddle snail hosts
- "2nd Intermediate Host" -- Semi-aquatic Vegetation
- **Juvenile flukes migrate throughout liver parenchyma (→ Acute DZ)**
- **Adult worms live in the bile ducts (→ Chronic DZ)**

Zoonosis

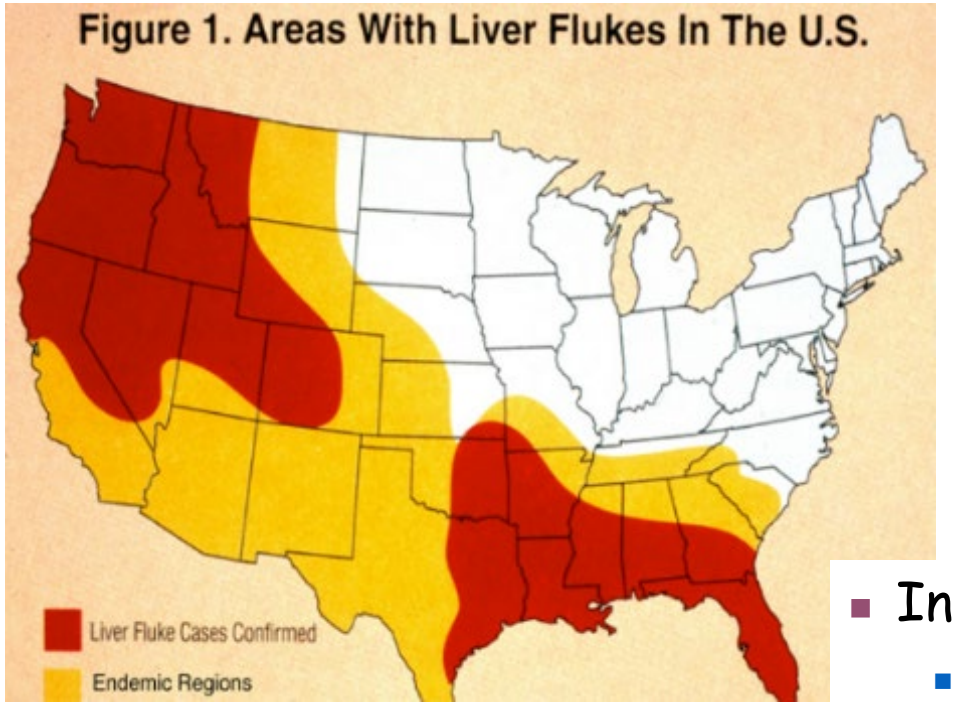
- Human Fascioliasis
  - Europe, Africa, Cuba, South America
- Halzoun (accidental zoonosis)
  - Ingestion of raw liver
  - Adult flukes attach to naso-pharynx
  - Middle East

Fasciola hepatica

Geographic Distribution



Orange - Worldwide distribution
Red - Most impacted by Fascioliasis



Dr. Foster_Liver Disease of Ruminants – VMP 962 lecture

- In USA
  - Gulf Coast States, Pacific Northwest, Eastern Canada
  - Not endemic in North Carolina (WHY?)

Fasciola hepatica

Pathology: Acute DZ

- Pathology is density dependent
  - Depends on number of infective larvae ingested
  - **Due to larvae migration in liver parenchyma**
- Acute (mainly an issue for Sheep & Goats)
  - > 2000 infective larvae over a short period
  - Seasonal issue in sheep and goats
  - Severe liver damage, hemorrhage, inflammation
  - CS: Distended, painful abdomen; unwilling to stand; acute anemic pallor; sudden death
- Subacute
  - 500 - 1500 infective larvae over a longer period
  - Death is not sudden
  - Extended period of liver damage prior to death
  - Death due to hemorrhage and anemia

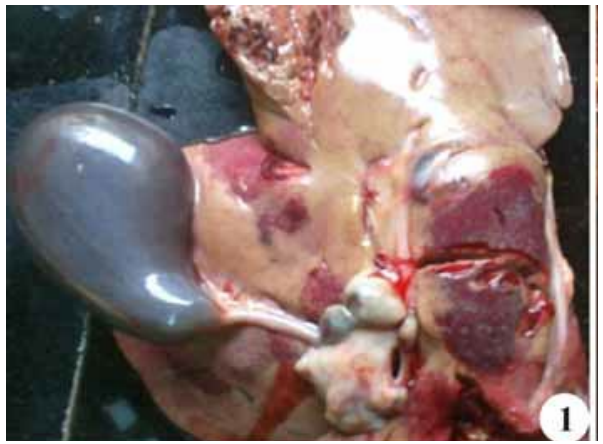
? What is a much more common parasite in small ruminants that causes these same clinical signs?

Acute: sudden death

Subacute: depression, weakness

Acute: anemic pallor

Distended, painful abdomen, unwilling to stand



Hemorrhagic tracts, pale liver, Gall bladder filled with blood

Fasciola hepatica
Pathology: Chronic DZ

- **Chronic (small ruminants, camelids & cattle)**
  - 200 – 500 larvae over a long period
  - **Due to adults in bile ducts**
  - Progressive liver damage
  - Anemia, hypoproteinemia
  - Bile duct fibrosis, stenosis
    - Eventual calcification
      - Pipe stem bile ducts

Fibrous tracks from the previous migrations of immature flukes

Bile duct calcification
"Pipe-stem liver"

Bottle Jaw

- **Clinical Signs**
  - **Cattle** - usually subclinical DZ
    - Chronic diarrhea, weight loss, bottle jaw
  - **Small ruminants & Camelids** - usually clinical DZ
    - Unthriftiness, rough hair coat, loss of condition, weakness, anemic pallor, bottle jaw.

Chronic diarrhea & weight loss

? What is a much more common parasite of cattle that causes these same clinical signs?

Bile duct Stenosis

Fasciola hepatica

Production Consequences

- Cattle
  - Economic loss
    - poor doers & liver condemnation
      - Reduced feed conversion, weight loss, reduced milk production, etc.
      - Liver Condemnations – ordered rankings:
        - Puerto Rico, FL, NV, OR, ID, UT, WA, CA
- Small ruminants and camelids
  - Acute DZ -- sudden death
  - Chronic DZ -- poor doers

Fasciola hepatica
Diagnostics

Any sign of potential *Fasciola* infection?

- Fecal Sedimentation
  - Chronic infections
- ELISA
  - Blood or fecal
  - Acute or Chronic infections
- Liver enzymes
  - elevated GGT (Gamma-glutamyl transferase)
- Herd History
  - Geographic origins
- Farm Observations
  - Ponds / puddles / swamps in pastures?
- Necropsy
  - Acute – hepatic hemorrhage and juveniles in the parenchyma
  - Chronic – bile duct stenosis and adults in the bile ducts

Fasciola eggs - Large, yellow to tan, operculate eggs

Even tractor ruts can be habitat for snail hosts

Fasciola hepatica
Treatment & Control

True or False.
Ivermectin is an excellent dewormer against Fluke or Tapeworm infections.

- Common Flukicides
  - Clorsulon (*Curatrem & Ivomec Plus*)
    - Kills adults and migrating juveniles
  - Albendazole (Valbazen Suspension PI)
    - Kills adults only

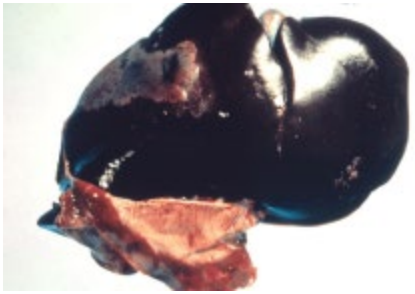
Strategic deworming is key to fluke control

- Considerations for Strategic Deworming
  - Whole cattle herd manipulations are time consuming & expensive.
  - Some treatments only kill adult flukes = 1.5 to 2 months post-infection
  - Most livestock losses occur 5-6 months post-infection
- Treat at the end of the transmission period
  - Gulf States
    - Transmission is in the winter thru early summer
    - Treat in mid-summer to late summer
  - Northwest
    - Transmission is highest in late spring thru fall
    - Treat in Winter

- Snail Control (unrealistic)
- Grazing Control
  - Restrict access to wet areas

Fasciola-associated diseases

Some bacterial diseases of livestock are associated with the hepatic migrations of the juvenile flukes.



Infectious Necrotic Hepatitis

- Necrosis from juvenile fluke migrations allows *Clostridium novyi* type B to cause Black Disease
- Primarily a disease of sheep & goats
- Acute Death
  - Depression, fever, tachypnea just prior to death

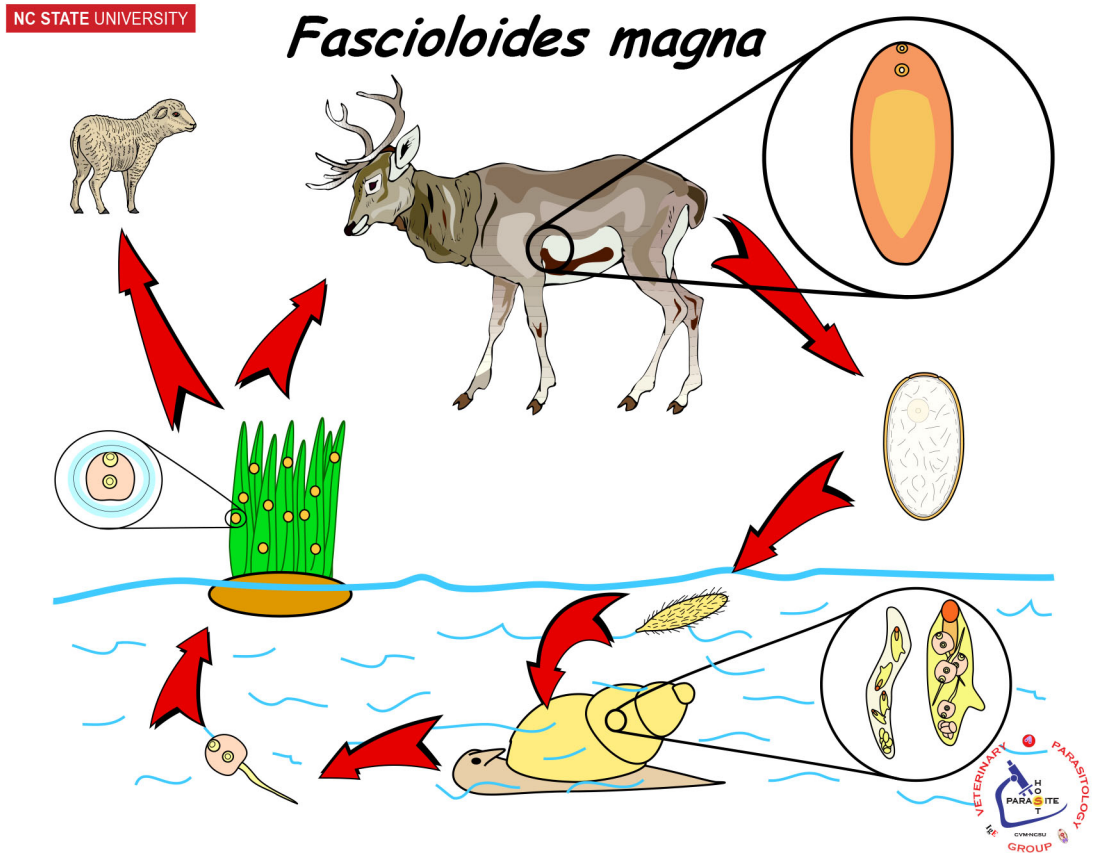
Bacillary Hemoglobinuria

- Necrosis from juvenile fluke migrations allows *Clostridium hemolyticum* to cause Red Water Disease
- Primarily a disease of cattle
- Acute Death
  - Depression, fever, tachypnea, hemoglobinuria, and icterus prior to death
  - Reddish urine

Fascioloides magna

Giant American Liver Fluke

Live flukes recently necropsied from a deer liver.



Life Cycle HIGHLIGHTS

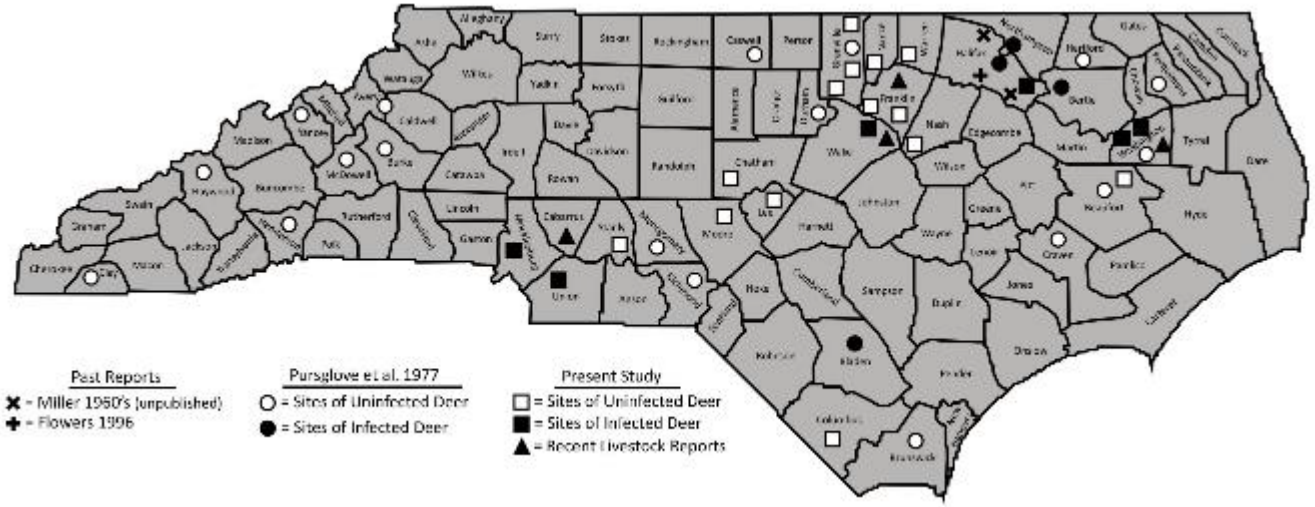
- Aquatic
- Definitive Hosts -- Cervids (deer, elk)
  - liver cavitations
- Pond / Puddle snail hosts
- 2nd Intermediate Host -- Semi-aquatic Vegetation

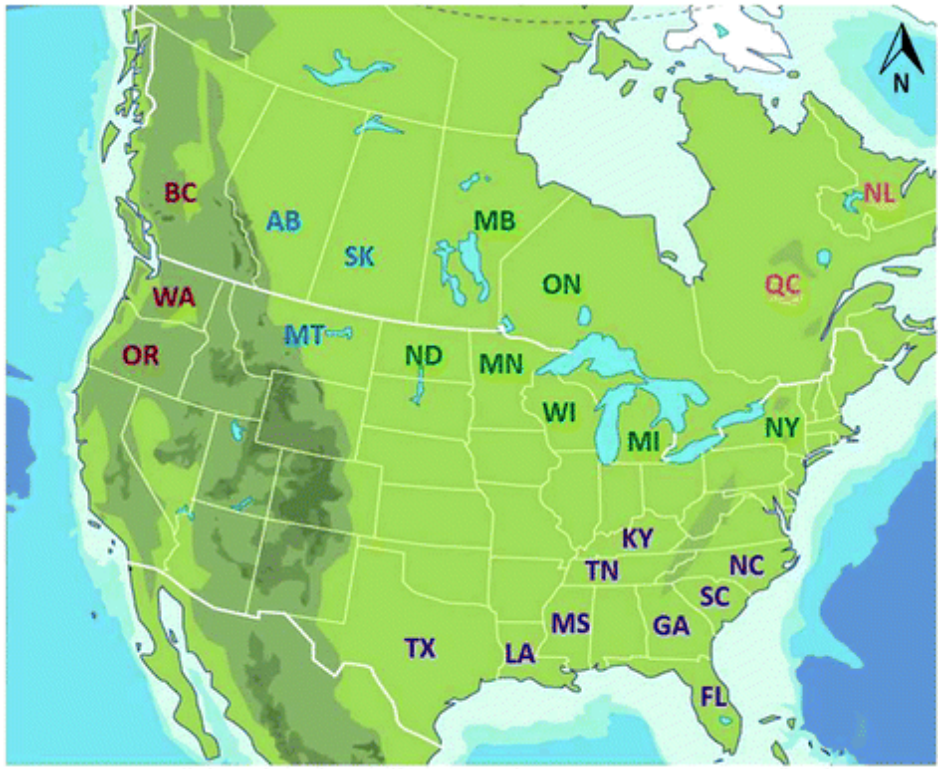
- Young flukes migrate through liver parenchyma before maturing in cysts with connections to bile ducts
- Dead-end Hosts (dead-end for fluke)
  - Sheep, Goats, Camelids: migration of young flukes cause liver damage & death
  - Cattle: Adult worms walled off in fibrotic cysts.
- Not Zoonotic

Fascioloides magna

Geographic Distribution

- Mainly endemic in wild cervid populations
- Scattered throughout US
- Prevents goat & sheep production in Minnesota & Michigan
- Sporadic in white-tailed deer in North Carolina
  - Recent goat, sheep, camelid, cattle infections in NC





- northern Pacific coast
- Rocky Mountain trench
- Great Lakes region
- northern Quebec and Labrador
- Gulf coast, lower Mississippi, and southern Atlantic seaboard

Fascioloides magna

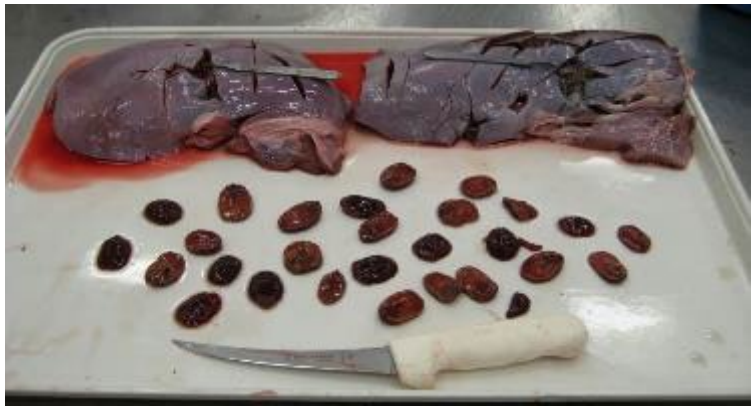
Pathology

- **Wild Cervids**
  - **Liver cavitations containing adult flukes and melanoid (hematin) fluid**
  - **Subclinical, unless very, very heavy infection**
  - **(118 flukes from 1 deer, but not debilitated) (Pursglove et al. 1977)**

Parenchymal, encapsulated, cavitated lesions, *Fascioloides magna*, liver. Black excretory pigment (hematin) deposited by the fluke.

Two *Fascioloides* from a fibrotic cavitation.

- **Sheep, Goats, & Camelids**
  - **Severe liver damage, hemorrhage, inflammation, sudden death**
  - **Juvenile migratory trauma may precipitate "black disease"**
- **Cattle**
  - **Subclinical, minor damage, unless very heavy infection**
  - **Liver Condemnations**



Live *Fascioloides magna* flukes necropsied from the livers of 2 white-tailed deer.

Melanoid (hematin) tracts from migrations.

Fascioloides magna

Diagnosis, Treatment, Control

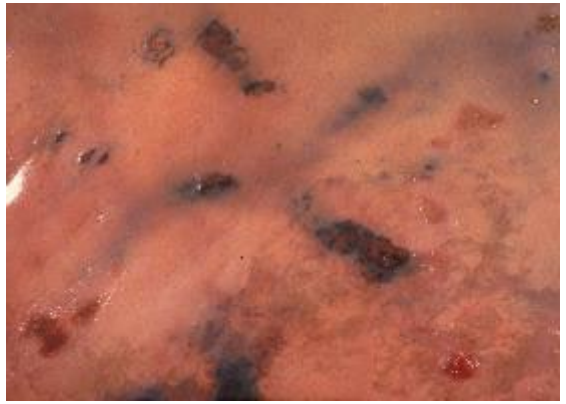
Wild Cervids

- Fecal Sedimentation
- Necropsy
- Treatment
  - Clorsulon *(Curatrem)*;
  - Albendazole *(Valbazen)*

Fascioloides egg from deer feces

- **Snail Control (unrealistic)**
- **Grazing Control**
  - Restrict livestock access to wet areas
  - Restrict wild cervids access to wet pastures

Melanoid tracts on surface of liver at necropsy



Domestic Ruminants

- (non-patent)
- Necropsy
- Wet pastures shared with wild cervids.
- No good treatment

In-Class Discussion

You are a large-animal vet in eastern North Carolina. An accountant, recently turned cattleman, is very concerned that he has lost much profit because of the condemnation of his cattle's livers. He was told by the abattoir meat inspector that many of his steers had "flukey livers".

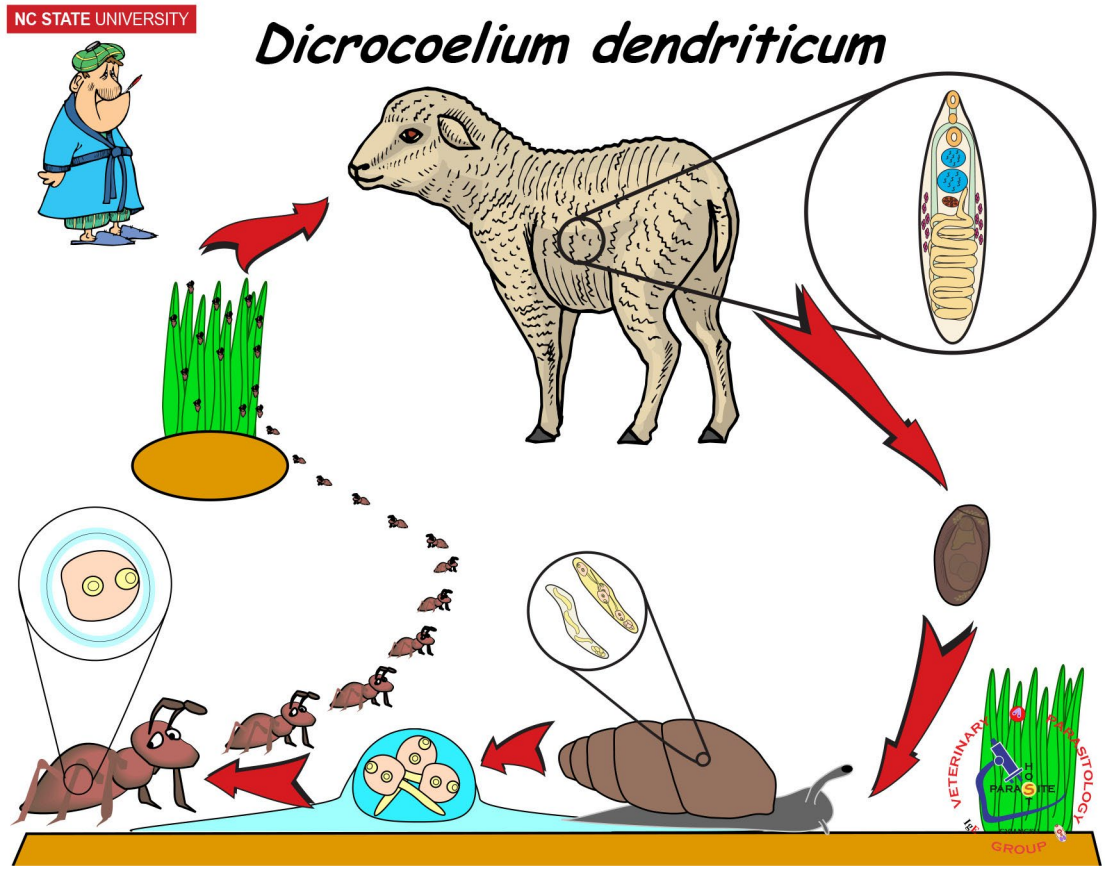
Worm differentials?

Contrast necropsy results?

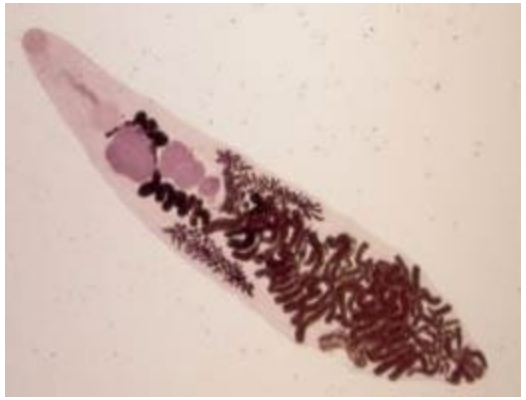
Contrast herd history, diagnostics, & farm visit observations?

Dicrocoelium dendriticum

Lancet Fluke



- **Hosts**
  - Terrestrial (1st – Land Snails & 2nd - Ants)
  - Small Ruminants (Sheep & Goats) – bile ducts
  - Variety of Hosts (cattle, camelids, rabbits, pigs, cervids, etc.)
- **Geographic Distribution**
  - Widely Distributed around the World
  - Northeast US & Canada
- **Pathology**
  - Non-pathogenic in younger animals
  - Bile duct hyperplasia, hepatic cirrhosis
  - Chronic wasting disease.
  - Decreased productivity in older animals (ewes)



- **Diagnosis**
  - Edema & emaciation in older stock
  - Ova in sedimentation
- **Treatment**
  - Albendazole, Praziquantel
- **Control**
  - Eradicate Ant hills
- **Zoonosis**
  - Yes - a few human cases

Trematode Table 1

Parasite	Definitive Host	1st Intermediate Host	2nd Intermediate Host	Pathology	Diagnostics	Control	Zoonotic ?
Fasciola hepatica Gulf Coast, Florida, Pacific NW	Ruminants 1. Young Flukes --Liver parenchyma ========== 2. Adult flukes --Bile ducts	Aquatic snails (pond/puddle)	Vegetation	1. Acute Hepatitis – Death ========== 2. Chronic -- Bile duct stenosis -- liver condemnation Black Liver DZ & Red Water DZ caused by associated Clostridial infections	Sedimentation & Necropsy Bottle jaw, anemia, may mimic Haemonchosis & Ostertagiasis	Dx Snails Dx wet pastures	Yes
Fascioloides magna Sporadic in US Endemic in NC	Deer ---------- Sheep & Goats ---------- Cattle	Aquatic snails (pond/puddle)	Vegetation	Minor ---------- Sudden Death (migrating young flukes) ---------- Liver condemnation (adults in pockets)	Sedimentation ---------- Necropsy ---------- Necropsy	Dx Snails Dx wet pastures Dx Deer	No
Dicrocoelium dendriticum Northeast US	Sheep & Goats (minor concern in cows)	Terrestrial Snails	Ants	Young hosts – minor Older stock -- decreased productivity due to liver dysfunction	Sedimentation & Necropsy	Dx Snails Dx Ants	Yes (rare)

Blood Fluke & Minor Flukes

Heterobilharzia americana
Nanophyetus salmincola
Acanthatrium oregonensis

Other Flukes

Take Homes

Heterobilharzia americana (Canine & Raccoon Blood Fluke)

- Special notes on Blood flukes
  - Dioecious = Male & female worms. No 2nd IH – larval stage skin-penetrates the DH
- Geographic range: Widespread in US, Endemic in NC
- DH: Raccoons, Dogs, other wildlife, Mesenteric Blood vessels.
- Snail Host: Aquatic puddle/pond snail. 2nd IH: None – Skin Penetration
- Pathology:
  - Adult flukes: minor pathology. Eggs : block blood vessels, intestinal infarctions, destruction of intestinal mucosa
  - Causes bloody diarrhea, wasting, & death
- Diagnosis: Saline Sedimentation, necropsy
- Control: No access to natural bodies of water. Zoonotic: yes, swimmers itch

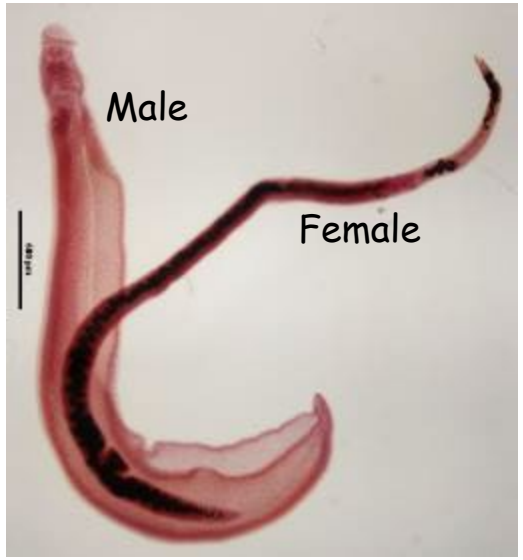
Nanophyetus salmincola

- Geographic range: Pacific Northwest
- DH: Canids (dogs, wolves, coyotes, fox, etc.) Snail Host: Aquatic river snail. 2nd IH: fish
- Special Note: Fluke carries *Neorickettsia helminthica* pathogen
- Pathology: Flukes: no pathology. Neorickettsia: Salmon poisoning, Severe pathology - hemorrhagic enteritis (50% to 90% mortality)
- Diagnosis: Fluke – sedimentation. Neorickettsia – Lymph aspirate
- Control: No raw fish. Zoonotic: Fluke - yes, Rickettsia - no

Acanthatrium oregonense

- Geographic range (GR): Sporadic in US
- DH: Bats Snail Host: Aquatic river snail. 2nd IH: caddisflies & may flies
- Special Note: Fluke carries *Neorickettsia risticii* pathogen
- Pathology: Flukes: no pathology. Neorickettsia: Potomac Horse fever. Horse – enteritis and colic
- Diagnosis: Bat – sedimentation. Neorickettsia in Horse – Rickettsial diagnostics
- Zoonotic: no

Heterobilharzia americana
Blood Fluke of Dogs

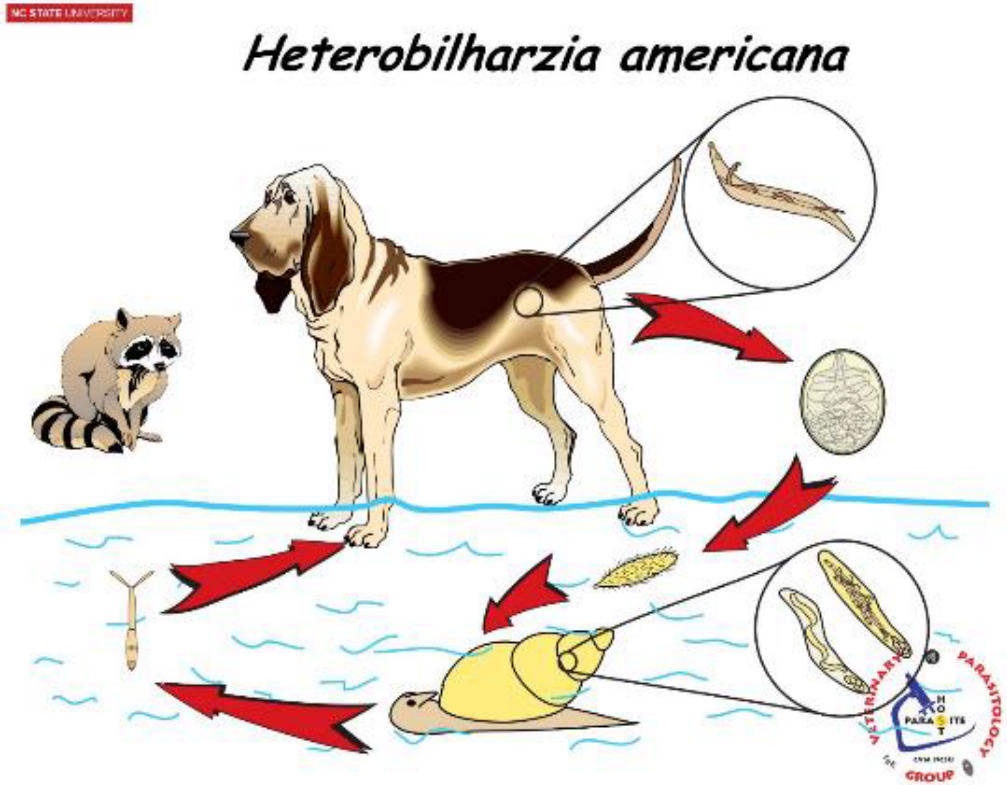


Unique morphology of blood flukes

- Dioecious elongate flukes.
- Female resides in the gynecophoric canal of the male.

Geographic Distribution

- Texas, Gulf Coast States, Georgia, South Carolina, North Carolina



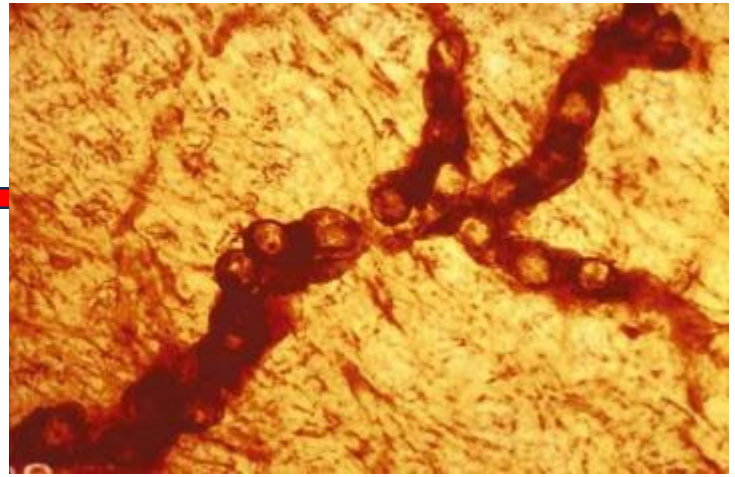
Life Cycle HIGHLIGHTS

- Aquatic
- Definitive Hosts -- Dogs & Raccoons (wild canids, bobcat, nutria, etc.)
  - Mesenteric veins
- Ova developed when passed & hatches when it enters water.
- Pond / puddle snails
- Skin Penetration (No 2nd Intermediate Host)

Zoonosis

- Swimmer's itch or Swamp itch
- Human Blood Flukes –*Schistosoma spp.*

Heterobilharzia americana
Pathology



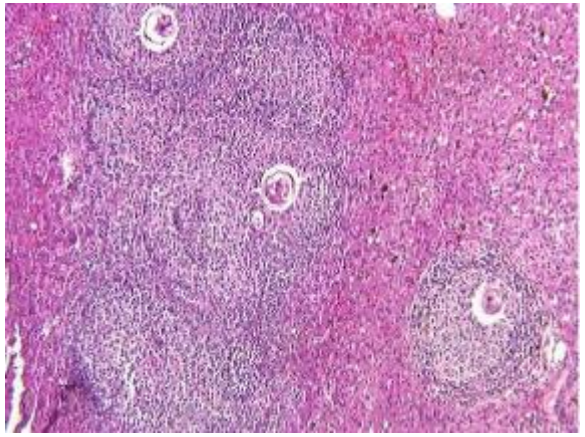
Eggs in Blood Vessels

Adult flukes

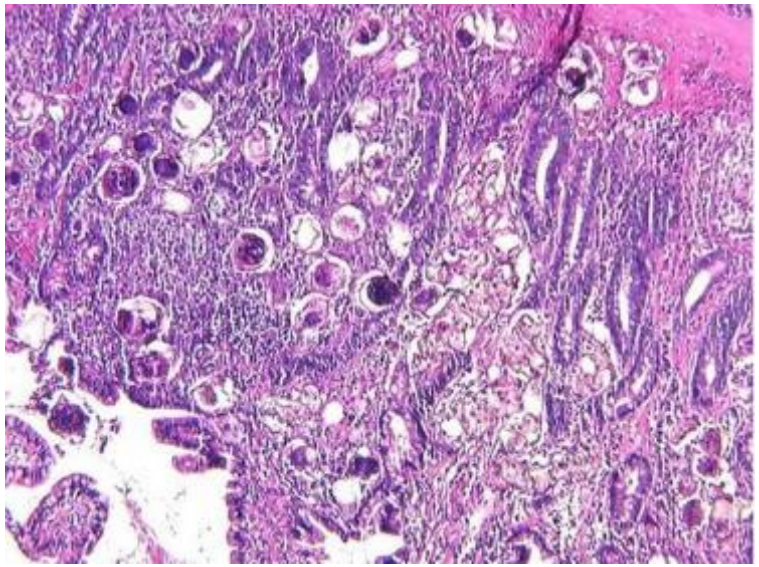
- Minor to no pathology.

Ova

- Eggs lodge in mesenteric venules
  - Infarctions, ischemia, destruction of intestinal mucosa.
  - Intestinal dysfunction that leads to wasting and death.
- Eggs transported to other organs.
  - Granulomatous reaction in liver and other organs
  - Inflammation & Fibrosis around eggs and egg clusters.



Eggs in Liver



Eggs in Intestinal Epithelium

Heterobilharzia americana

Diagnosis, Treatment, Control

Egg

Miracidium

- Clinical signs: lethargy, anorexia, intermittent vomiting, bloody liquid diarrhea, dehydration.
- Fecal saline sedimentation or smear.
- Miracidial Hatching
- Laparotomy
- PCR fecal test from Texas A&M http://vetmed.tamu.edu/gilab/service/assays/heterobilharzia-americana
- History of possible access to water habitats while in endemic areas.
- Water-Loving Breeds

- Fenbendazole *(Panacur)*: 40 mg/kg daily for 10 days
- Praziquantel *(Droncit)*: 25 mg/kg daily for 2-3 days

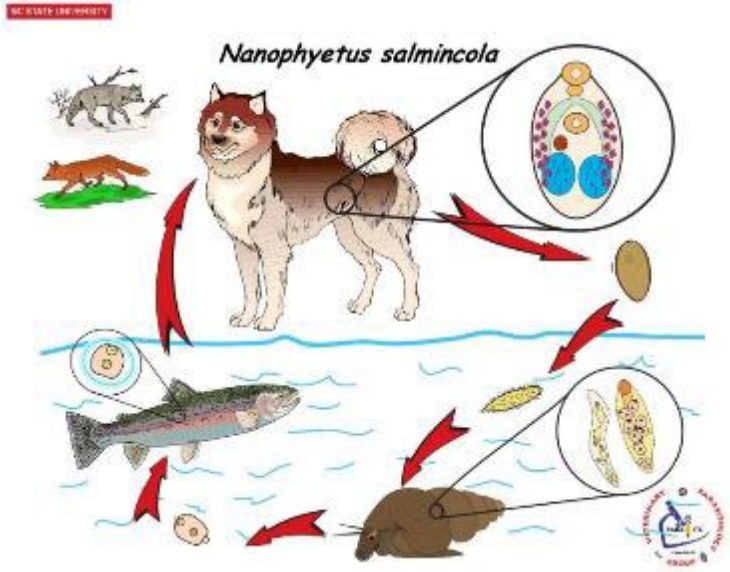
- Prevent access to freshwater habitats (ponds, lakes, streams, creeks, rivers, ditches, etc.)

Infested Habitat (Confirmed)

Nanophyetus salmincola

Salmon Poisoning Fluke

- Life Cycle -- aquatic
  - Canids (Small Intestine)
  - River snails
  - Fish (Salmon / trout)
- Pacific Northwest (WA, OR, north CA)
- Vector for Salmon Poisoning
  - Affects Canids only
  - *Neorickettsia helminthoeca*
    - Severe pathology - hemorrhagic enteritis
    - (50% to 90% mortality)



Acanthatrium oregonense

Potomac Horse Fever Fluke

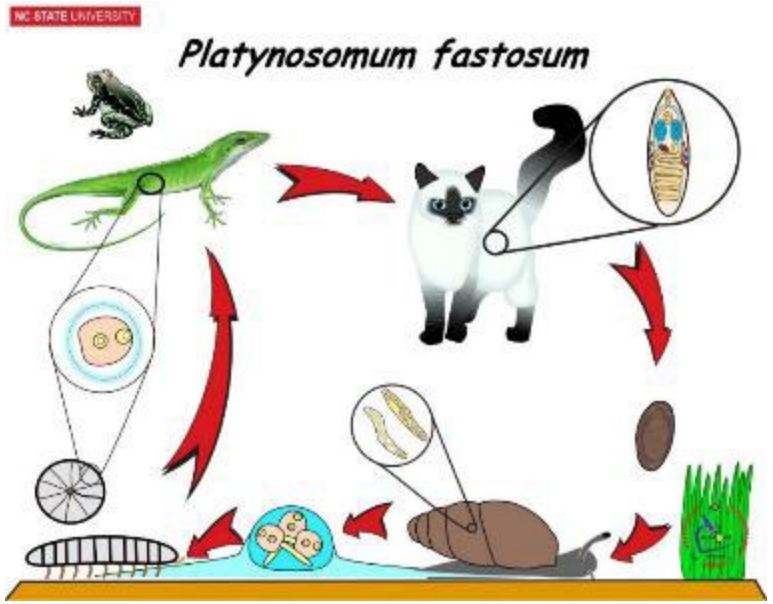
- Life Cycle -- aquatic
  - Bats (small intestine)
  - River snails
  - Caddisflies & Mayflies
  - Horse (dead-end host)
    - Accidental ingestion of caddisflies or mayflies infected with fluke metacercariae that are infected with *Neorickettsia. risticii*
- Sporadic throughout US
- Vector for Potomac Horse Fever
  - *Neorickettsia risticii*
    - Colitis — diarrhea, fever, depression

Platynosomum fastosum

Bile Duct Fluke of Cats

- Life Cycle -- Terrestrial
  - Cats (Bile ducts)
  - Land snails
  - 2nd: Roly-Poly bug
  - Paratenic: Lizards or toads
- FL, HI, Caribbean, Malaysia, South America, Central America, Caribbean, West Africa
- No pathology → mild, temporary inappetence with hepatic dysfunction → progressive icterus & possibly death. ("lizard poisoning")
- Clinical signs: diarrhea, jaundice, vomiting.

FYI

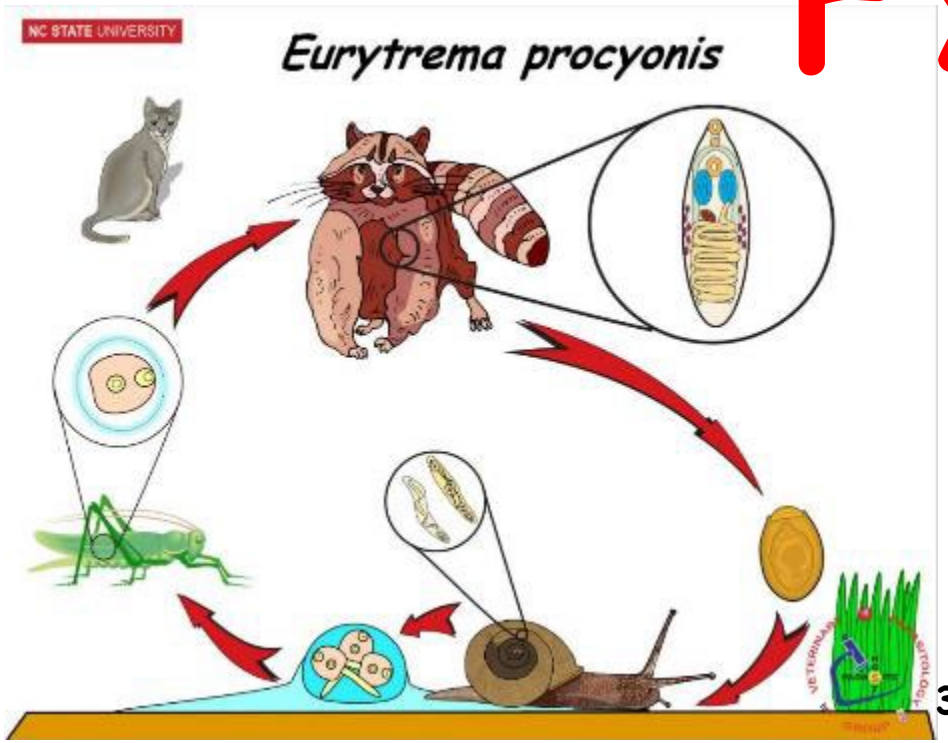


Eurytrema procyonis

Pancreatic Fluke of Cats

- Life Cycle -- terrestrial
  - Cats (Pancreatic duct) [Raccoons, Fox, Bobcats]
  - Land snails
  - Grasshoppers & Crickets
- Sporadic (NY, CT, MD, KY, NC)
- Pathology - Pancreatic duct fibrosis, Pancreatic atrophy
- Clinical Signs: Vomiting & chronic weight loss

FYI



Trematode Table 2

Parasite	Definitive Host	1st Intermediate Host	2nd Intermediate Host	Pathology	Diagnostics	Control	Zoonotic ?
Paragonimus kellicotti Throughout US	Dog & Cats Racoons, other wildlife Lungs	Aquatic snails (river)	Crayfish	1. Pulmonary inflammation --- Respiratory signs 2. Pneumothorax / sudden death	Sedimentation	Dx Snails Dx access to crayfish (rivers, ponds, streams)	Yes
Heterobilharzia americana Widespread in US Endemic in NC	Dog Raccoon Mesenteric Blood vessels	Aquatic snails (pond/puddle)	None (Direct cercaria penetration)	Adult fluke – minor Eggs – block vessels, infarctions, destruction of intestinal mucosa (Bloody diarrhea, wasting, death)	Saline Sedimentation	Dx access to standing water (ponds, streams, ditches)	"Swimmer's itch"
Nanophyetus salmincola Pacific NW	Canids Small intestine	Aquatic snails (river)	Fish	Fluke Minor --- Salmon Poisoning *Neoricketsia helminthica* severe DZ & death	Sedimentation --- Lymph aspirate	Dx Snails Dx access to fish	Fluke: Yes --- Rickettsia: No
Acanthatrium oregonensis Sporadic in US	Bats (Horse – dead-end accidental host)	Aquatic snails (river)	Caddisflies & Mayflies (accidentally ingested by horse while grazing)	Bat – minor --- Horse – Potomac Horse Fever – *Neorickettsia risticii* Enteritis & colic	Bat – Sedimentation --- Horse – diagnose rickettsial DZ	N/A	No


VETERINARY
PARASITOLOGY
HOST
PARASITE
IgE
CVM-NCSU
GROUP