Pathology and internal parasites

Most parasites extraordinarily well adapted to natural host species

Trypanosomes – Wyoming cervids
Non-pathogenic

Trypanosomes – human sleeping sickness
Chronic disease
Disease mechanism #1: Dose makes the poison

- Heavy infestations
- Overwhelming tolerance and/or immunity of natural host species
- Compounding:
  - + Stress
  - + Malnutrition
  - + Crowding
- Example: heartworm (*Dirofilaria immitis*)
- <25 adults: no clinical signs
- Higher infestations:
  - Pulmonary hypertension + right sided heart failure
  - Pulmonary embolism

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Parasite gastroenteritis

<table>
<thead>
<tr>
<th>Parasite</th>
<th>Normal host</th>
<th>Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Large strongyles</em></td>
<td>Horses</td>
<td>Enteritis</td>
</tr>
<tr>
<td><em>Small strongyles</em></td>
<td>Horses</td>
<td>Enteritis</td>
</tr>
<tr>
<td><em>Coccidiosis</em></td>
<td>Ruminants/pigs</td>
<td>Enteroaditis</td>
</tr>
<tr>
<td><em>Necrocytoplasia</em></td>
<td>Nematodes</td>
<td>Vasculitis; abortion</td>
</tr>
<tr>
<td><em>Large roundworms</em></td>
<td>Horses; pigs</td>
<td>Enteritis (obstruction)</td>
</tr>
<tr>
<td><em>Lungworms</em></td>
<td>Multiple dom. and wild ruminants</td>
<td>Pneumonia</td>
</tr>
</tbody>
</table>

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Heartworm – *Dirofilaria immitis*
Ostertagia-induced abomasitis

Coccidiosis - goat

D. viviparus - lungworm
Disease mechanism #2
Lesions induced by migration in normal host

- Many parasites migrate extensively in host tissue
- Most:
  - Minimal tissue damage
- Some:
  - Local or generalized tissue injury
  - Going to wrong site

Ascaris suum – "milk spots"
Mechanism #3: susceptible age range

<table>
<thead>
<tr>
<th>Young more susceptible</th>
<th>Older more susceptible</th>
</tr>
</thead>
<tbody>
<tr>
<td>Porcine coccidiosis</td>
<td>Bovine babesiosis</td>
</tr>
<tr>
<td><em>Isospora suis</em></td>
<td><em>B. bovi</em> and <em>B. bigemi</em></td>
</tr>
<tr>
<td>&lt;2 days – highly susceptible</td>
<td>&lt;9 months – no disease</td>
</tr>
<tr>
<td>&gt;2 weeks: little or no disease</td>
<td>&gt;9 months – hemolysis</td>
</tr>
</tbody>
</table>

Factor:  
- Maturation of villi and villous enterocytes  
- Better cell and antibody mediated immunity  

Pathogenesis:  
- Direct RBC destruction  
- Osmotic lysis  
- Basis for age-related susceptibility undefined

Mechanism #4: wrong host species infected

- Parasites vary in specificity of definitive host, intermediate host  
  - Most: highly specific and adapted  
  - Some: poorly adapted:  
    - Effective host response and elimination  
    - A few:  
      - Induce disease – often dependant on immunity or dose of ingested parasite
Parasitic disease in aberrant species

<table>
<thead>
<tr>
<th>Parasite</th>
<th>Normal host</th>
<th>Abnormal host</th>
<th>Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Paradiplogastrostrongylus tenuis</em></td>
<td>WTD</td>
<td>Other cervid species</td>
<td>CNS</td>
</tr>
<tr>
<td><em>Elaeophora schneideri</em></td>
<td>Mule deer</td>
<td>Elk and moose</td>
<td>CNS/extremities</td>
</tr>
<tr>
<td><em>Ascaris suum</em></td>
<td>Domestic pig</td>
<td>Humans</td>
<td></td>
</tr>
<tr>
<td><em>Toxocara canis</em></td>
<td>Dog</td>
<td>Humans</td>
<td>CNS/ocular</td>
</tr>
<tr>
<td><em>Echinococcus multilocularis</em></td>
<td>Aortic for/dog (D)</td>
<td>Rodents (I)</td>
<td>Lung</td>
</tr>
<tr>
<td><em>Echinococcus granulosus</em></td>
<td>Dog (D)</td>
<td>Sheep (I)</td>
<td>Brain; lung; liver</td>
</tr>
<tr>
<td><em>Angiostrongylus spp.</em></td>
<td>Dog</td>
<td>Humans</td>
<td>Skin</td>
</tr>
<tr>
<td><em>Baylisascaris procyonidis</em></td>
<td>Raccoon (D)</td>
<td>Rodents</td>
<td>CNS</td>
</tr>
<tr>
<td><em>Trichinella spp.</em></td>
<td>Pigs; Bears</td>
<td>Humans</td>
<td>GIT/muscle</td>
</tr>
<tr>
<td><em>Dirofilaria canis</em></td>
<td>Dog</td>
<td>Foxes, cat</td>
<td>Heart</td>
</tr>
</tbody>
</table>

Elaeophorosis (carotid worm)

**Normal host species:**
- Mule deer
- Black-tailed deer
- Sub-adults and adults:
  1. Meningeal vessels
  2. Carotid arteries
- Microfilaria: skin of head
  ○ Unusually large

**Abnormal host species:**
- Elk
- Moose
- White-tailed deer
- Domestic sheep

**Pathology:**
- Vascular occlusion
- Infarction
- Primarily:
  - Brain
  - Eyes
  - Skin of head (esp. sheep)
Echinococcosis

4/8/2011

Cutaneous larva migrans

4/8/2011

Female and male Baylisascaris procyonis

MRI – brain, 11 month old boy

4/8/2011
Dirofilaria in ferret

Meningeal worm - Parelaphostrongylus tenuis

Right host species but wrong strain

- African animal trypanosomiasis
- T. congolense, T. vivax and T. brucei subsp. brucei
- Natural resistance (‘trypanotolerance’)
  - Native African cattle breeds and wildlife
- Susceptibility:
  - European cattle breeds and wildlife
- Disease due to anemia, lymphadenopathy and weight loss
Mechanism #5: hemolysis

- Important class of parasites:
  - Human:
    - Malaria – *Plasmodium* spp.
  - Domestic/companion animal:
    - Piroplasmosis – *Babesia* spp.
    - East Coast fever - *Theileria* spp.

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Malaria

- Highly successful:
  - Human: 500 million infected; 1 million death/year
  - Avian and mammals:
    - Most important blood parasite worldwide
    - >40 species in birds
    - Poorly studied except as laboratory models of human infection
- Alternate mosquito and vertebrate hosts
- Major clinical consequence: anemia (hemolysis)
  - CNS disease
  - Effects on spleen and liver
- Highly endemic areas: risk mostly to infants, young children, pregnant women and visitors

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Malaria in humans

- Four species routinely infect humans
  - Most important: *P. falciparum*
- Multiple life stages
- Multiple strains within each *Plasmodium* sp.
- Basis for successful parasitism:
  - Partial host resistance = widespread endemic infection
    - Exp. hemoglobinopathies (SC trait; α- and β-thalassemia)
  - Absence of sterilizing immunity
    - Multiple infections (≥5/year) over 10 – 15 years needed to develop clinical immunity
    - Hypnozoites in liver
- Variant surface antigens after infection:
  - PfEMP1
Mechanism #5: manipulating immune response

- Example: lymphatic filariasis
- Direct effect on T regulatory cells
  - ↓ Th1 and Th2 responses (most individuals)
  - High microfilarial loads
  - Little or no lesions
- Immune effects disappear following treatment – actively induced
- Induction of ineffective immunoglobulin class (IgG4)
- ↓ antigen handling by macrophages
- Clinical disease associated with death of nematodes:
  - Immuneological ‘over-responders’
  - Medication
Major life stages of filarial worms

- Infectious larvae
  - Transmitted by mosquito
- Adult worm
  - Develop from larvae
  - Lymphatic vessels vs. circulation vs. subcutaneous tissue
  - Long-lived (4 – 40 years)
- Microfilaria
  - Produced by mated adults
  - Nocturnally active – O2 tension vs. circadian rhythm (host vs. parasite)
    - In lungs during day
    - Survive host bloodstream for up to 1 year
    - Acquired by mosquito develop into infectious larvae

Disease syndromes associated with lymphatic filaria in humans

- Lymphatic filariasis/lymphangitis:
  - Major syndrome
  - In those individuals over-reacting to adults in lymphatics
  - End result: lymphangitis
  - Risks of using medication
- Tropical pulmonary eosinophilia:
  - Minor syndrome
  - Individuals over-reacting to microfilaria in lungs
  - Genetic host factors
Variations on a theme

- Excessive reaction to microfilaria in eyes:
  - River blindness (*Onchocerca volvulus*)

Mechanism #6: inappropriately vigorous inflammation

- Example: schistosomiasis
  - Severe inflammatory reaction to schistosome eggs
  - T_{H1} response helpful to host early in infection
  - T_{H2} response after 5 – 6 weeks of egg laying
    - Soluble egg antigens invoke T_{H2} response
  - Outcome: periportal fibrosis, hepatosplenomegaly and ascites
Immune responses to schistosomes

- Adult fluke:
  - Lives largely undetected in blood vessels for 8 – 10 years

- Fluke eggs:
  - 50% excreted
  - 50% carried to portal circulation
  - Induce vigorous inflammatory reaction
  - \( T_2 \) type eosinophilic granulomas