Pathology of external parasites

‘External’ parasites for the purposes of lecture

- External on skin surface:
  - Temporary and permanent parasites
- External on mucosal surfaces, esp. GIT
  - Parasites
  - Limited or no penetration of mucosa
- Importance of surface immunity, including mucosal and innate
- External parasites becoming internal parasites as they explore new niches

The challenge of being an external parasite

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
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<tbody>
<tr>
<td>Limited exposure to acquired immune system</td>
<td>Exposure to innate immunity:</td>
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<tr>
<td>Access to surface nutrients</td>
<td>Many external parasites</td>
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<tr>
<td>Consistent environment</td>
<td>species-specific</td>
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<tr>
<td>Ease of transmission to new hosts</td>
<td>Importance of attachment</td>
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<td></td>
<td>Nutrition sources short-lived or limited</td>
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Important surface parasites (skin)

<table>
<thead>
<tr>
<th>Permanent</th>
<th>Transient</th>
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<tbody>
<tr>
<td>- Lice</td>
<td>- Diptera (flies)</td>
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<tr>
<td>- Mites</td>
<td>- Mosquitoes</td>
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<tr>
<td></td>
<td>- Black flies</td>
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<tr>
<td></td>
<td>- Midge</td>
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<td></td>
<td>- Blowflies and flesh flies</td>
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<td></td>
<td>- Horseflies/deer flies</td>
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<td></td>
<td>- Arachnids</td>
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<tr>
<td></td>
<td>- Ticks</td>
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<tr>
<td></td>
<td>- Fleas</td>
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</tbody>
</table>

Important surface parasites (mucosal)

- Coccidia:
  - Eimeria
  - Isospora
- Giardia
- Cryptosporidium
- Trichomonas
- Multiple economically important nematodes
  - Haemonchus
  - Ostertagia
  - Trichostrongylus

Feeding insects

- Direct injury and allergic reactions
- Transmission of other pathogens
Fleas and pathology

- Intermittent feeding
- Most common allergic dermatitis in companion animals
- Type I and IV hypersensitivity reaction to saliva
  - Histamine-like compounds, enzymes, polypeptide, amino acids
  - Eep. neck (cats); lumbar sacral area (dogs)
  - IgE and IgG antibodies within 2–12 weeks of exposure
- Secondary self-trauma

Demodicosis

- Demodectic mange
- Common
  - Well adapted in many species
- Inhabit:
  - Hair follicles
  - Sebaceous glands
- Often asymptomatic
- Breed-related infections
  - ?Defective T-cell immunity
  - Altered self-antigens (keratinocytes)
- Secondary bacterial infections
Scabies

- Sarcoptes scabei
- Species specific
- Typical scabies:
  - Controlled infection
  - Th1 cell-mediated protective response
- Crusted scabies:
  - Exuberant infection
  - Nonprotective Th2 allergic response
  - Hypersensitivity
  - Eosinophilia

Ticks, feeding and disease

- Two major tick families
  - Hard ticks – Ixodidae
  - Soft ticks – Argasidae
- Feeding periods:
  - Hours (soft ticks)
  - Days (hard ticks)
- Barbed feeding tube
- Cement-like substance
- Anesthetic saliva inserted
- Introduction or acquisition of pathogens

- Tick-borne illnesses:
  - Viral:
    - Many flaviviruses (louping ill)
    - ASF
  - Bacterial:
    - Tularemia
    - Lyme disease
  - Parasitic:
    - Anaplasmosis
    - Babesiosis
    - Ehrlichiosis
Tick salivary components

- Alternation of blood ingestion and salivation
- Salivary components:
  - ~500 proteins (hard ticks); 150 – 200 proteins (soft ticks)
  - Secreted at different times during feeding
- Interference with hemostasis
  - Vasoconstriction (= vasodilators)
  - Platelet aggregation
  - Fibrin cascade (= fibrin binding to platelets)
- Minimize inflammation:
  - Binding histamine, serotonin, Ig and complement
  - ‘Anesthesia’
    - Neutralization of ATP, serotonin, histamine, bradykinin

Ghost moose syndrome

- *Dermacentor albipictus*
  - Winter tick
- Affected:
  - Moose – grooming behavior
  - Also: caribou, elk
- Causes:
  - Blood loss
  - Disturbed eating
  - 40 – 80 % hair loss
- Tick burden:
  - >30,000 ticks (moose)
  - 2 ml/female tick
  - Remove liters of blood
Botflies

- Example: *Oestrus ovis*
- Similar parasites in cattle (*Hypoderma* spp.), horses (*Gasterophilus* spp.), rodents/lagomorphs (*Cuterebra* spp.)
- Deposition of larvae in nasal cavities
- Maturation in nasal sinuses

Coccidiosis

- Direct life cycle
  - *Eimeria* and *Isospora*
  - Highly species-specific
  - Asexual and sexual stages
  - Differences in location in gut
  - Different location along villi
  - Multiple species:
    - Sheep: 11 with 2 pathogenic
  - Importance of merogony:
    - Lysis of host cell
  - Extra-intestinal stages (limited)

Cryptosporidiosis

- Highly successful parasite
  - Multiple species affected
    - Birds; fish; amphibians; mammals
  - Autoinfection cycle
  - Apical organelle discharge
  - Sporozoite-specific lectin adherence factor
  - Microvillous surfaces
  - Parasitophorous vacuole
  - Villous atrophy
  - Malabsorption diarrhea
Trichomonas

Coccidia – exploring new niches:

Non-enteric coccidia
- In some:
  - Intra-nuclear
  - Endothelial cells
  - Local lymph nodes
  - Bile ducts/liver
  - Stomach
  - Placenta
  - Other

Extra-intestinal coccidia
- Sarcocystis spp.
  - Use prey-predator cycle
- Toxoplasma:
  - Infect everyone
- Neospora:
  - Try vertical transmission

Prey-predator cycle: sarcocystosis

Predator:
- Typical coccidial life cycle
- Sexual stage
- Minimal extra-intestinal invasion
- No clinical disease

Prey species:
- Extra intestinal cycle
- Intravascular:
  - Merogony
  - Acute vascular disease
- Intramuscular:
  - Cyst stage
  - Acute myositis
Toxoplasmosis

- **Definitive host:**
  - Cat
  - Recurrent infections

- **Intermediate host**
  - Asymptomatic → symptomatic
  - All warm blooded animals
  - Generally, minimal disease
  - Cyst formation:
    - Brain; muscle; liver
  - Disease when:
    - High challenge doses
    - Susceptible species
    - Immunosuppression
    - Fetus infection

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Pathogenesis of toxoplasmosis

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<thead>
<tr>
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<tbody>
<tr>
<td>Direct cell lysis</td>
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<tr>
<td>No toxins produced</td>
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<tr>
<td>Tachyzoites:</td>
</tr>
<tr>
<td>Rapidly proliferating</td>
</tr>
<tr>
<td>Most pathogenic</td>
</tr>
<tr>
<td>Short-lived; extracellular</td>
</tr>
<tr>
<td>Bradyzoites:</td>
</tr>
<tr>
<td>Cyst stage</td>
</tr>
<tr>
<td>Quiescent</td>
</tr>
<tr>
<td>Long-lived; intracellular</td>
</tr>
<tr>
<td>Domestic animals:</td>
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<tr>
<td>Sheep: abortion</td>
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<tr>
<td>People: abortion, encephalitis, chorioretinitis</td>
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</tbody>
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Definitive host
- Cat: no signs
- Rarely disease

Strategies used by *T. gondii*
- Large number of susceptible host species
- Ease of transmission
  - Vertical and horizontal
  - Water-borne
  - Food-borne
- Infection of multiple organs
- Preferential infection of monocyte/macrophage cells
- Parasitophorous vacuole
  - Recruitment of host mitochondria and RER
- Arrest of cell at G2/M stage of cell cycle
- Antigen differences between tachyzoite and bradyzoite
- Use of cell stress (IFN) signals to encyst
- Antigenically silent cystic stage
- Encysting in long-lived cells (myocytes; neurons)
Neosporosis

- **Definitive host:**
  - No lesions
- **Intermediate hosts:**
  - Abortion
- **Vertical transmission**
- **Abortion:**
  - Myocarditis
  - Encephalitis
  - Placentitis

Immunity and mucosal nematodes

- **Th2 or Th1/Th2**
  - Mast cells + eosinophils + IgE antibodies
  - Histamine leukotrienes, bradykinin
  - Direct cell killing by eosinophils
  - Parasite-specific IgA
- **Degranulation + inflammatory mediators ‘flush’ larvae from gut**
  - Peristalsis
  - Mucus secretion
- **Diversity of nematode antigens**
  - Acquired immunity slow to develop
  - Rarely complete

Antagonist

- IgG, IgE
- IL-4, IL-5, IL-13

Antebody production

Parasite-directed away from mucosal growth

Expulsion of nematode challenge
Important surface nematodes (internal)

- Hematophagus vs. mucosal browsing
- Essentially 100% of sheep and cattle infected
- Effects due to:
  - Inappetence
  - Diarrhea
  - Re-partitioning essential amino acids

Pathogenesis of parasitic gastroenteritis

- Major impacts:
  - Subclinical weight loss, reduced weight gain, reproductive inefficiency
- Age-related susceptibility:
  - Early, young stock and stressed older animals
- Phenotypic resistance:
  - Poorly defined
  - Familial
- Immunity:
  - Typically Th2 response
  - Limited practicality based on vaccine studies
- Immune exclusion:
  - Established population makes less host susceptible to infection
- Self cure:
  - Expulsion of adults after heavy larval exposure
  - IgE-induced

Haemonchus contortus

- Abomasal parasite
  - L2
  - L3
  - Adult
- Different antigenic profile for each
- L3 in abomasal glands
- Two forms of disease:
  - Type 1
  - Type 2