APICOMPLEXA 1

General Characteristics of Apicomplexa

A. Select Characteristics
- Intracellular with apical complex – organelle for invasion of host cell
- Gliding motility
- Life cycle alternates b/w sexual and asexual phases
- Many morphological stages

B. Morphology by stage
- Zoite
  - Tear-shaped (cylindrical with pointed anterior and blunt posterior)
  - Sporozoite (infective stage) & merozoite (reproduce in host cells and can infect new host cells)
    - Other “zoites” (not all apicomplexa will include these)
      - Bradyzoite = slow growing stage
      - Tachyzoite = fast growing stage
  - Extra-cellular and invasive stages
- Troph
  - amoeboid (various shapes)
  - trophozoite
  - Intra-cellular, feeding, metabolically active
- “-ont”
  - a “bag” of Zoites
- “ont”
  - meront (= schizont), gamont
  - intracellular

C. Replication
- Asexual Reproduction, different forms include:
  - Endopolygeny = multiple cycles of nuclear division followed by cytoplasmic division
    - Sporogony (sporulation): replication within the oocyst resulting in sporozoites; usually only 1 round of replication
    - Merogony: (aka: schizogony) is replication of merozoites; usually many rounds of replication
  - Endodyogeny = single nuclear division followed by cytoplasmic division, forming 2 fully-formed daughter cells within the cytoplasm of the mother cell
- Sexual Cycle
  - Gametogony: merozoite develops into a gamete
    - Microgamete = male (replicates asexually)
    - Macrogamet = female
  - Fertilization = microgamete fertilizes a macrogamete and develops into a zygote or oocyst

C. Taxonomy
1. Conoidasida – conoid apparatus, infect intestinal cells, oocyst stage
   a. Gregarinasina (Primitive, mainly infects invertebrates)
      i. Cryptosporidium spp. --- direct life cycle
   b. Coccidiasina (common coccidians)
      i. Eimeria --- direct life cycle
      ii. Cystoisospora & Toxoplasma --- direct LC or facultative indirect LC (paratenic hosts)
      iii. Sarcocystis -- obligate indirect life cycle (requires intermediate host)
2. Aconoidasida – no conoid apparatus, infects blood cells, indirect LC w/ blood feeding arthropods
   a. Piroplasmidia -- transmitted by Ixodid ticks
      i. Babesia, Theileria, Cytauxzoon
   b. Haemosporida – transmitted by biting flies
      i. Plasmodium, Haemoproteus, Leucocytozoon
Apicomplexa of Intestinal Pathology

Cryptosporidium, Eimeria, Cystoisospora

Cryptosporidium parvum
Pathogenic Crypto of Cattle, but very low host specificity

A. Morphology
- Very small oocyst (5-8 um) with 4 sporozoites, already sporulated when passed
- “Superficial” parasite of the microvillus of gut cells (enterocytes)

B. Life Cycle
1. Transmission
   a. Direct life cycle – fecal-oral, ingestion of oocyst
2. Invasion
   a. Sporozoites excyst from oocyst and invade microvillus border of enterocyte
3. Asexual reproduction
   a. Merogony (schizogony) [multi-nuclear division followed by cytoplasmic division]
   b. Merozoites exit the enterocyte and infect the microvillus border of other enterocytes and goes through merogony again.
   c. Number of asexual cycle: unknown, (probably variable depending on host response.)
4. Sexual reproduction
   a. Final generation of merozoites exit the enterocyte and infect the microvillus border of other enterocytes and go through gametogony (production of gametes)
   b. Macrogamete (egg)
      i. Some final merozoites remain a single cell and become a macrogamete (egg) within a macrogamont.
   c. Microgametes (sperm)
      i. Other final merozoites go through multi-nuclear division, cytoplasmic division, and develop 2 flagella (bi-flagellate) on each gamete; thus forming a microgamont
      ii. Exflagellation – when microgametes exit the microgamont in search of a macrogamete.
   d. Fertilization – a microgamete fuses with a macrogamete forming a zygote
   e. A cyst wall forms around the zygote and the immature oocyst exits the macrogamont into the lumen of the host’s gut.
5. Sporogony (= Sporulation)
   a. The zygote, within the oocyst, goes through sporogony, forming 4 sporozoites.
   b. Sporulation occurs within the lumen of the host gut, thus making the oocyst immediately infectious.
6. Dissemination
   a. Thin-walled Oocysts
      i. Some oocysts have thin cyst walls and excyst within the gut of the same host
         1. thus autoinfection causing low grade chronic pathology (diarrhea)
         2. in the immunocompromised this may allow for hyperinfection and acute severe pathology / mortality.
   b. Thick-walled Oocysts
      i. Some oocysts have thick cyst walls and exit the host in the feces
         1. thus contamination of the environment and transmission to the next host.
         2. infectious when passed.

C. Pathogenesis = intestinal epithelial injury
1. Villus atrophy and dysfunction of absorptive enterocytes decrease absorption and surface area
2. Crypt hyperplasia causes increased secretory activity
3. Increased inflammatory cells (inflammation) increase permeability, with loss of fluids in to the gut lumen.
D. Clinical Disease (“Calf Scours”)
1. Complaint -- Mild to severe diarrhea, usually in neonatal calves - first 3 weeks of life
   a. most often reported in calves from 5-15 days of age.
   b. persistent infection may cause marked weight loss and emaciation.
2. Pathological findings
   a. large amounts of watery diarrhea (cholera-like diarrhea)
   b. feces yellow or pale, watery, and may contain mucus.
   c. subsequent severe dehydration, anorexia, debilitation.
3. Usually self-limiting in immunocompetent hosts
4. Severe & lethal in immunodeficient hosts
5. Differential Diagnoses for “Calf Scours”
   a. Bovine viral diarrhea virus (BVDV)
   b. Coccidia
   c. Cryptosporidium
   d. Salmonella
   e. Clostridium
   f. E. coli
   g. Nutritional causes

E. Diagnosis
1. Centrifugation with Sheather’s solution (sugar solution -higher specific gravity than cysts so they
   float to the top and debris sink)
   a. very small oocysts -- focus on the thin layer of fluid above bubbles
   b. don’t confuse with yeast
2. Thin fecal smear with special staining (acid fast stains)
3. Serology and molecular diagnostics: Fluorescent antibodies, ELISA, PCR

F. Treatment
1. Some drugs are suppressive against Cryptosporidium (Paromomycin, Azithromycin, etc.)
2. Fluid-replacement therapy for the dehydration that is caused by the diarrhea.

G. Control
1. Sanitation, especially for young calves, and provide adequate amounts of colostrum
   a. Hutch system for dairy calves
2. Sanitation & hygiene for humans and others
3. Oocysts are viable for months unless exposed to extreme temperatures, drying, or disinfectants
4. No Vaccines

H. Epidemiology
1. C. parvum in Calves
   a. Primarily in neonatal calves, but also in lambs, kids, foals, and piglets, as well as in humans
      (zoonotic)
   b. Prevalence of 70% in 1-3 week old dairy calves
   c. Calves 9-14 days old most likely to excrete oocysts.
   d. A concurrent infection with rotavirus and coronavirus tends to make disease worse, than with
      Crypto. alone.
2. Other Crypto. species are less pathogenic and may be more host-specific
   a. (ex. C. felis, C. canis, C. hominis)

I. Zoonosis
1. C. parvum is highly zoonotic
2. Transmitted to human to human
   a. direct contact with animals
   b. water-borne infection from contamination of water sources with animal feces.
   c. Farm workers at high risk.
3. Waterborne municipal out-breaks, as well as food-borne outbreaks
   a. There is also a human-specific Cryptosporidium hominis (formally known as C. parvum
      genotype 1)
4. Highly dangerous for immunocompromised patients.