Protozoa Transmitted by Arthropod Vectors

Many Arthropods (flies, mosquitoes, ticks & fleas) can act as vectors in transmitting disease causing organisms to vertebrates

**Mechanical Vector**
- Transmit a disease causing organism from one host to another by carrying it on/in its mouth parts or on its body
- e.g. Horse flies (Tabanus) transmit equine infectious anemia on their mouthparts

**Obligatory or Biological Vector**
- Disease organism undergoes some degree of development within the arthropod vector
- Obligatory vectors can also act as a definitive host or intermediate host depending on the type of development the disease organism undergoes
- e.g. *Plasmodium* undergo sexual reproduction in the Anopholene mosquito, thus the mosquito is both an obligatory vector and definitive host

**Hemoflagellates**
- Species of the genera *Trypanosoma* & *Leishmania* are of veterinary importance
- During one stage of the life cycle they live in the blood &/or tissues of the vertebrate host and during another stage they live in the intestines of bloodsucking arthropods
- They are either elongate with a single flagellum or rounded with a non-protruding flagellum
- All possess a kinetoplast which is sausage or disc-shaped and contains mitochondrial DNA

**Trypanosomiasis**

**Causative agent & Host Range**

Trypanosomes are divided into two groups or “sections” based on their development within the arthropod vector

**Section Salivaria**
- Trypanosomes undergo development in the anterior station or front portion of the digestive tract of the arthropod
- Trypanosomes are transmitted to the vertebrate host in the saliva of the arthropod host
- e.g. *Trypanosoma brucei* & *T. congolense* transmitted by tsetse flies in Africa and cause Nagana, a fatal disease of domestic cattle

**Section Stercoraria**
- Trypanosomes undergo development in the posterior station or hind portion of the digestive tract of the arthropod
- Trypanosomes are transmitted to the vertebrate host in the feces of the arthropod host
- e.g. *Trypanosoma cruzi* transmitted by triatomine bugs (also called reduviid bugs or “kissing bugs”) and cause Chagas disease in Central & South America as well as the southern USA

**Trypanosoma cruzi - Chagas Disease (Zoonosis)**

**Morphology**

**Trypomastigote**
- Slender, 16 - 20 µm long with a pointed posterior end
- Kinetoplast located near posterior end & flagellum is long & runs out the anterior end
- Undulating membrane (formed from the flagellum running through the body) is narrow
- found in circulating blood of vertebrate host

**Amastigote**
- Spheroid, 1.5 - 4.0 µm, lack flagella
- Develop within muscle & other tissues in clusters

**Epimastigote**
- Flagellated with the kinetoplast located between the nucleus & anterior end
- Found in the posterior portion of a triatomine bug’s gut

**Life Cycle**
- Triatomine bug feeds on a blood meal from the vertebrate… it then defecates
- Feces may contain trypomastigotes (metacyclic trypomastigotes) in the hind gut
- Trypomastigotes enter the host’s body through the bite wound through scratched skin or mucus membranes when the vertebrate host rubs the bite wound
- Trypomastigotes first enter the blood stream & then enter cells of the spleen, liver, lymphatics, cardiac, smooth & skeletal muscle
- Once inside the cell, transform into a amastigote & reproduce by repeated longitudinal binary fission
- Amastigotes are released when the host cell lysis,
- Amastigotes then transform back into trypomastigotes & may either enter new cells locally or into general circulation
- Triatomine bugs feeding may then ingest trypomastigotes with their blood meal
- Trypomastigotes then enter the posterior portion of the bugs gut & reproduce by binary fission as epimastigotes
- Metacyclic trypomastigotes are found in the rectum of the bug 8 - 10 days post blood meal & can now infect a vertebrate host
Life cycle of *Trypanosoma cruzi* in humans

**Epidemiology**
- Distribution:
  - Central & South America and Mexico (infects 12 - 19 million people)
  - has been found in Maryland, Georgia, Florida, Texas, Arizona, New Mexico, California, Alabama and Louisiana
- Prevalence in USA is low and disease episodes are sporadic
- Dogs can suffer clinical signs of disease, but cats, armadillos, opossums and racoons can serve as reservoirs for the disease

**Pathogenesis**
- Host cell destruction by multiplying amastigotes accompanied by local inflammatory response results in degeneration and necrosis
- Nerve cells in the vicinity, ganglion cell in particular are often affected
**Clinical signs**

**Acute disease**
- **Dogs** - lymphadenopathy, myocarditis, pale mucus membranes, lethargy, hepatosplenomegaly, and tachyarrhythmia

**Chronic disease**
- **Dogs** - congestive myocardial failure as the heart becomes enlarged and flabby
- **Humans** - megasyndromes (megacolon, megaesophagus) can result from destruction of autonomic ganglia (therefore destroys tonus of the muscularis)

**Diagnosis**
- Detection of trypomastigotes in blood smear or lymph within 5 weeks of infection
- In chronic infections
  - culture, serology (IFA) or xenodiagnosis (allow naive triatomine bugs to feed on host then look for parasites in bug’s gut)

**Treatment & Control**
- Does not respond well to treatment (only extracellular parasites killed, i.e. intracellular stages unaffected by treatment & serve as a source of recrudescence of disease)
- nifurtimox, benzimidazoles & allopurinol may be tried during acute phase of disease
- Insecticides to control, limit exposure to arthropod vectors
- Avoid contact reservoir animals (e.g. skunks, raccoons, opossums…armadillos).

**Leishmaniasis (Zoonosis)**

**Causative agent & Host Range**

*Leishmania* spp. transmitted by sandflies (*Phlebotomus* in the Eastern Hemisphere & *Lutzomyia* in the Western Hemisphere)

Several clinical forms of leishmaniasis in humans, dogs, rodents & wild mammals
- Visceral leishmaniasis
- Cutaneous leishmaniasis
- Mucocutaneous leishmaniasis

Endemic in the tropics, visceral leishmaniasis reported in a number of English & American Foxhounds throughout the USA, Southern Ontario & Nova Scotia

*Leishmania* species are morphologically identical

Infections in North America Foxhounds caused by *Leishmania donovani* species complex
**Morphology**

**Promastigote** - found in the gut of the vector & have a forward extending flagellum & the kinetoplast is located near the anterior end of the body

**Amastigote** - spheroid, lack flagella, 2.5 - 5.0 μm & found in the vertebrate hosts tissue

**Life cycle (Leishmania donovani)**

- *Leishmania* promastigotes inoculated into the skin of the vertebrate in the saliva of the feeding sandfly
- *Leishmania* organisms are engulfed by vertebrate macrophages where they multiply rapidly by longitudinal binary fission, destroying the macrophage
- Once released by the macrophage, the amastigotes are engulfed by new macrophages & the cycle continues, eventually leading to severe damage of the host reticuloendothelial system
- When the sand fly vector ingests the amastigote along with a blood meal they become lodged in the midgut of the insect & multiply by binary fission
- Amastigotes transform into promastigotes in the sand fly oral/proboscis where they can infect a new host during the next blood meal

---

**Life cycle of Leishmania spp. in humans**

VPM-122 Protozoa Transmitted by Arthropod Vectors & Arthropod Parasites– Winter 2017
**Epidemiology**
- *Leishmania* is endemic in the Mediterranean (Southern France, Spain & Italy), Asia, South & Central America
- *Leishmania* reported in Foxhounds in Oklahoma, Texas, Ohio, New York & Ontario with a seroprevalence of 41% in a New York colony
  - **vertical** (transplacental/transmammary) or **horizontal** (contact with blood)
  - transmission can occur via blood transfusion, therefore using Foxhounds as blood donors may be unadvisable
- **Important zoonotic disease as dogs can act as a reservoir for human infections!**

**Pathogenesis**
- Destruction of reticuloendothelial system leads to susceptibility to secondary pathogens
- Spleen & bone marrow undergo compensatory production of macrophages to the detriment of RBC production which results in hepatosplenomegaly

**Clinical signs**
- Variable & non-specific, visceral & cutaneous forms can occur alone or combination
- Epistaxis, seizures, hair loss, abnormal nail growth, skin lesions (ulcers), swollen limbs & joints
- Chronic wasting, kidney failure, liver failure
- Death

**Diagnosis**
- Amastigotes detected on fine needle aspirates of lymph nodes, bone marrow & spleen
  - BUT are often negative even when the dog is infected
- Current tests available are:
  - Immunofluorescent Antibody test (IFA) & Enzyme-Linked Immunosorbent Assay (ELISA) for detection of antibodies to parasite in serum
  - qPCR for detection of parasite

**Control & Treatment**
- Treatment is difficult & current drugs do not cure the disease
- Drugs used in an attempt to reduce the clinical signs of disease
  - Meglumine Antimoniate with Allopurinol, Aminosidine & Amphotericin B
- All drugs require multiple dose regimens & will depend on the patient's condition & owner cooperation
- Relapse is common & may occur weeks, months or years later
- **Vector control is essential (regardless of role of vertical or horizontal transmission)**
  - Use of insecticide collars, shampoos or sprays
  - Especially in patients under treatment
  - Residual insecticide spraying of houses & animal shelters may help
**Piroplasmosis**

Piroplasms: intracellular apicomplexan parasites of vertebrate blood cells- transmitted by ticks

**Causative Agent & Host Range**

**Bovine piroplasmosis**
*Babesia bigemina* - Babesiosis, Texas fever or red-water fever
- Serious & often fatal disease of cattle worldwide
- eliminated in the USA since 1940 due to eradication of vector *Boophilus annulatus*

*Babesia bovis, Babesia divergens, Babesia argentina*
- causes red-water fever throughout the world except in Canada & USA
- *B. bovis* is more pathogenic than *B. bigemina* in Australia & Mexico

**Theileria spp.**
- Important pathogens of cattle in Africa, Southern Europe & Asia
- *Theileria parva* causes East Coast fever in African cattle with significant mortality

**Canine piroplasmosis**
*Babesia canis, Babesia gibsonii*
- Cosmopolitan in distribution & cause of occasional disease in dogs in the USA
- Vector - brown dog tick *Rhipicephalus sanguinensis*

**Feline piroplasmosis**
*Cytauxzoon felis*
- Sporadic but usually fatal disease of domestic cats in South-Central USA
- Bobcat is the natural reservoir for the disease & the American dog tick, *Dermacentor variabilis*

**Equine piroplasmosis**
*Babesia caballi, Babesia equi*
- cause acute or chronic disease of horses worldwide and occasionally in the USA

**Human piroplasmosis**
*Babesia microti*
- Normally a parasite of voles & mice,
- Human infections have occurred in North-Eastern USA, *Ixodes scapularis* is the vector

**Morphology**

*Babesia spp.*
- merozoites are found in the erythrocytes of the vertebrate host
- Piriform 3 - 5 µm long amoeboid & 2 - 4 µm in diameter (size is species dependent)
- Blue cytoplasm with red chromatin mass when stained with Wright-Giemsa

_Cytauxzoon felis_
- Signet-ring like forms found in erythrocytes 1 - 1.2 μm in diameter
- Merozoites 0.1 - 0.2 μm in diameter may be found within monocytes in spleen, lymph nodes, lungs, liver and kidneys

**Life Cycle**
- Sporozoites transmitted to vertebrate host as a tick feeds
  - Longer the vector is attached, the greater the chance of sporozoite transmission
- _Babesia_ sporozoites then infect erythrocytes, become trophozoites & multiply by binary fission
- _Theileria & Cytauxzoon_ sporozoites first invade a lymphocyte & then undergo schizonts and merozoites are released from lysed lymphocytes which then go on to infect erythrocytes
- Merozoites released from ruptured erythrocytes infect new erythrocytes & this cycle can continue indefinitely
- Some trophozoites do not reproduce but instead increase in size & become gametocytes
- Following ingestion by a tick vector, the gametocytes undergo fusion (sexual reproduction) to produce an okinete (zygote) which enters an epithelial gut cell of the tick
- From the tick gut the zygote enters the salivary acini of the tick or invades the ovaries (from where it is transmitted transovarially)
- Within the salivary acini, sporozoites develop (sporogony) which may be transmitted to the vertebrate host when the tick feeds

- Merogony & the first stage of Gametogony (Gametogony I) occur in the vertebrate host
- Gametogony II & Sporogony occur in the tick
Epidemiology

**Babesia spp.**
- Disease is rare, but seroprevalence of 46% has been reported in Florida greyhounds & 55% in pit bull terriers in South-Eastern USA

*Cyauxzoon felis*
- Disease occurs sporadically in South-Eastern & South-Central USA but natural infections in cats result in near 100% mortality

Pathogenesis

**Babesia spp.**
- Destruction of erythrocytes resulting in hemolytic anemia
- Clogging of capillaries in various organs by parasitized cells & free parasites results in anoxia, accumulation of toxic metabolites, hemorrhaging & organ failure
**Cyauxzoon felis**

**Leukocytic phase** (mononuclear cells & macrophages)
- Leukocytes become engorged with schizonts resulting in blood flow obstructions in the liver, lung, lymph nodes, spleen & bone marrow

**Erythrocytic Phase**
- Destruction of erythrocytes leading to hemolytic anemia

**Clinical signs**
- Hemolytic anemia, depression, anorexia, pyrexia, splenomegal, icterus, dehydration
- *Cyauxzoon* is a rapidly progressing fatal disease in cats

**Diagnosis**

**Babesia spp.**
- Observation of trophozoites within erythrocytes on stained blood smears (collect blood from ear or toe nail as parasites are more common & numerous in capillary blood)
- History, clinical signs, serology

**Cyauxzoon felis**
- History & clinical signs
- Detection in stained peripheral blood smear or tissue impression smear (leukocytic phase)

**Control & Treatment**
- Tick control to prevent infection
- *Babesia* - diaminazene I.M. or phenamide S.C.
  - these drugs are not approved for use in horses
- *Cyauxzoon* - no treatment has proven effective
Malaria is caused by a number of Apicomplexan parasites in the genera *Plasmodium*, *Haemoproteus*, & *Leucocytozoon*

**Causative agent & Host Range**

*Plasmodium spp.*
- Malaria in humans & non-human primates, rodents, birds & reptiles
- Transmitted to mammals by anopheline mosquito & to birds by culicine mosquito
- 300-500 million people are infected with malaria each year
- 1-3 million people die from malaria each year
- 90% of deaths due to *Plasmodium falciparum*

*Leucocytozoon spp.* (over 60 species known to infect birds)
- Malaria of domestic & wild birds transmitted by the black fly, *Simulium* spp.
- *L. simondi* infects ducks & geese, *L. caulleryi* infects chickens, *L. smithi* infects turkeys

**Leucocytozoon**

**Life cycle**
- Sporozoites transmitted to the vertebrate host when the black fly feeds
- Sporozoites travel via blood to the liver, brain, spleen or lungs & undergo schizogony
- Merozoites released when infected cells rupture, they then infect erythroblasts, erythrocytes, lymphocytes, monocytes & vascular endothelial cells
- Merozoites in erythrocytes develop into round gametocytes while those in macrophages & vascular endothelial cells form megaloschizonts up to 400 µm in size
- merozoites released from megaloschizonts invade leukocytes & develop into elongate gametocytes
- Gametocytes ingested by the black fly during feeding undergo further development, fusion & sporogony within the gut & salivary glands
Life cycle of *Leucocytozoon simondi*


**Epidemiology**
- *L. simondi* infections have been reported in ducks & geese throughout Canada & USA
- *L. smithi* has been reported in turkeys in North America & is widespread in adult turkeys in the Southern USA
- *L. caulleryi* infections have only been reported in South Carolina (common in Japan & South-East Asia)

**Pathogenesis**
- Destruction of infected host cells results in anemia, leukocytosis, splenomegaly & hepatomegaly
- Gross visible white dots in affected organs = megaloschizonts
- Obstruction of circulatory system by infected cells & parasites

**Clinical signs**
- Young birds - most susceptible with acute onset of anorexia, listlessness, laboured breathing, anemia, diarrhea (with green droppings)
  - Significant death loss within 24 hours of clinical signs
  - Typically appear 10 - 19 days post exposure
- Older birds - chronic infections with low mortality, but can become listless & thin
  - Decreased egg production, egg weight & hatchability
  - Recovered birds harbour parasite in blood for over a year & often for life

**Diagnosis**
- Microscopic observation of gametocytes in stained thin blood smears or identification of schizonts in tissue sections, along with clinical signs & history
- PCR test (research only)

**Control & Treatment**
- Control black fly vector to prevent infections
- Keep domestic birds separated from wild birds (reservoir)
- Treatment is usually not effective
- Preventive medication is the norm;
  - sulfadimethoxine & pyrimethamine combinations
  - clopidol approved by the FDA for control of infections in turkeys
Veterinary Ectoparasitology – Arthropods Parasites

Arthropods are a diverse group of invertebrates & compose > 80% of known animal species
Occupy every known habitat & display every type of life style including parasitism

Arthropod groups of veterinary importance:
Arachnids (Class Arachnida)
- Ticks, mites, spiders & scorpions
Insects (Class Insecta)
- Flies, fleas, lice, mosquitoes, gnats, bugs & beetles
Crustaceans (Class Crustacea)
- Copepods, Isopods, Amphipods, crabs, lobster

Morphology
Arthropods defined by presence of seven features:
  1- Segmentation - can be reduced in many classes (i.e. mites)
  2- Exoskeleton - made from a cuticle containing chitin
  3- Jointed limbs - some of which may be vestigial
  4- Tagmatisation - division of body into segments (head, thorax & abdomen)
  5- Dorsal blood vessel
  6- Haemocoel - central cavity containing blood (hemolymph)
  7- Ventral nerve cord

Arthropod development
- Exoskeleton is a barrier for growth therefore undergo periodic moultng or ecdysis
- Stages between mouls referred to as instar (e.g. larval instar) until sexually mature

Life Cycles
Growth & maturation from egg to adult can take place via a number of pathways

Hemimetabolous (simple life cycle)
- Juveniles (nymphs) are similar to adults in appearance & feeding habits
- Arthropod sheds its cuticle at different intervals throughout development, increasing in size until emerging as an adult

Holometabolous (complex life cycle)
- Increasing functional & structural divergence from juvenile to adult
- Juvenile stages bear no resemblance to the adult & upon reaching the final juvenile stage, pupation occurs within a puparium or cocoon with the adult form ultimately emerging from the puparium
Ectoparasitism - Effects on the host

Ectoparasites have a number of direct & indirect effects on their host

Direct effects
- Blood loss
- Myiasis (infestation of living tissue with fly larvae)
- Skin inflammation & pruritus
- Toxicosis & allergic responses

Indirect effects
- Disturbance
- Self-wounding
- Social nuisance
- Vectors
Ticks (Acari)

Ticks are obligate blood feeding ectoparasites of vertebrates

Ticks are arachnids & are closely related to mites

The ticks of veterinary importance are contained in two families

- Ixodidae - the hard ticks
- Argasidae - the soft ticks

**General characteristics**

**Ixodidae**
- Dorsoventrally flattened bodies (when unfed) divided into two sections
  - **Capitulum** (gnathosoma)
    - Anterior cephalothorax
    - bears mouth parts (chelicerae, palps & hypostome)
    - capitulum of ixodid ticks is visible in the dorsal view
  - **Idiosoma**
    - contains the internal organs & bears the legs (3 pairs in larval stage, 4 pairs in nymphs & adults)
    - Posterior portion may be subdivided into sclerites called festoons
- Ixodid ticks are sexually dimorphic with females being larger than males
- Both sexes possess a sclerotized dorsal shield called a **scutum**
  - Males - scutum covers the entire dorsal surface
  - Females - scutum only partially covers the anterior portion of the dorsal surface

**Argasidae**
- Argasid ticks have a leathery body & are unsclerotized
- Capitulum of argasid ticks is **not** visible in the dorsal view
- There is little sexual dimorphism amongst argasid ticks
Generalized Anatomy of Hard Ticks (Ixodidae)
Dorsal view - Male (top left), Dorsal view - Female (top right)
Ventral view (bottom centre)

Generalized Anatomy of Soft Ticks (Argasidae)
Dorsal view (left), Lateral view (centre), Ventral view (right)

Generalized Tick Mouth Parts
Dorsal view (left) & Ventral view (right)
**Mouth Parts**

Both ixodid & argasid ticks possess specialized mouth parts for attachment & feeding

**Chelicera**  
- Appendages located within sheaths on each side of the mouth  
- used to cut & pierce the host’s skin

**Palps**  
- function as sensory organs & may aid in feeding by stabilizing the tick

**Hypostome**  
- extends anteriorly & ventrally from the basis capituli (somewhat like an underlip)  
- Armed with backward directed teeth & acts as an anchoring device during feeding

**Feeding**

Some ticks are host specific, but most are opportunistic & will feed on a variety of hosts  
- Palps are used to grasp the skin while the chelicerae cut  
- Hypostome is thrust into the wound & teeth used to anchor the tick to the host (some ticks also secrete a cementing substance that further secures them to the host)  
- Blood & lymph from the lacerated tissues well up into the wound & are sucked up  
- During feeding, ticks secrete large amounts of saliva which contain anticoagulants & as a mechanism to dispose of surplus fluid from the blood meal  
- Argasid ticks feed rapidly while ixodid ticks feed for days

**Life History**

**Ixodidae**

Life cycle involves 4 instars:  
egg - larva - nymph - adult
Life cycle may take 6 weeks to 3 years to complete
- **Mating usually takes place on the host** & following a blood meal the engorged female drops to the ground & lays large batches of eggs over a period of days to weeks (thousands of eggs/batch)
- **Larva** (six-legs) emerges from the egg & climbs to the tips of vegetation where they ‘quest’ for a host
- Ticks detect hosts through sensory cues
  - **CO₂** detected by **Haller’s organ** (chemoreceptors) located near the tip of their first pair of legs
- After attaching to a host, the tick larva feeds, taking 4 - 6 days
- Once feeding is complete the **larva mouls to nymph** (eight-legs)
- After the nymphs feed they moult to become adults

- If the ticks moult through all instars on a single host they are termed; **One-host ticks**
- If the nymph drops off the host to moult, then quests & attaches to a new host they are termed; **Two-host ticks**
- If the larva & nymph both drop off to moult the tick is termed; **Three-host ticks**
  - Note: in multi-host tick life cycles the “host” maybe the same animal, a different animal of the same species or a different species…

- Ticks are extremely hardy & can withstand long periods of starvation
- Ixodid ticks may spend as little as 10% of their time on the host (3-host tick) & often must “quest” for long periods of time before encountering a new host
- Feeding & generation cycles synchronized with periods of suitable temperature & humidity

Argasidae

- Argasid ticks live in close proximity to their hosts (in contrast to Ixodid ticks which do not)
- They spend less time finding a host & will feed frequently if possible
- Most argasid ticks have a **multi-host life cycle**
  - Adults mate away from the host & feeding occurs several times
  - Females lay small batches of eggs (400-500) after each feeding
  - Larvae feed once then moult to the first stage nymph
  - Typically between 2-7 nymph stages, each one feeding then leaving the host to moult

Pathogenesis

There are several ways ticks cause harm to their hosts

Anaemia & Tick Worry
- Anaemia - blood loss in heavy infestations considerable
  - loss of 200 lbs. of blood in large hosts has been reported
- Tick worry – ill thrift caused from loss of blood, pain & swelling from the bite wounds, secondary infections & absorption of toxins

Dermatosis
- Inflammation, swelling, ulceration & itching can result from components of tick’s saliva & mouthparts that remain in the wound (when improperly removed)

Tick Toxicosis (Paralysis)
- Some species of ticks cause an ascending paralysis due to injection of a neurotoxin in the saliva which disrupts motor nerve synapses in the spinal cord & blocks neuromuscular junctions
- A single tick can produce paralysis in humans & dogs, but heavy infections are required to produce paralysis in cattle
- Clinical signs do not appear unless the tick has been feeding for approximately four (4) days & removing the ticks can often result in dramatic recovery

Vectors
- Ticks transmit a number of bacterial, viral & protozoal pathogens
- Pathogens may be passed **transstadially** (from larva to nymph & nymph to adult) or **transovarially** (from female to next generation)
General Treatment & Control

Removal
- **Tick checks**: ticks may be removed by grasping them as closely to the animal’s skin as possible (forceps or fingers may be used) & exert steady, gentle traction

Dogs & cats
- **Host-targeted**: Topical products (selemectin & fipronil) or spray (fipronil)
- Application of topical pesticides (sprays, dips, powders) if animal is heavily infested
- Flea-tick collars (do not work well - regional i.e. the neck)
- **Environment**: pet premises can be treated with pesticides with residual activity, destruction of refugia on property near kennels, house…

Livestock
- **Host-targeted**: application of pesticides to animals (sprays, dips, powders, backscratchers, ear tags)
- Ivermectin, moxidectin, eprinex, doramectin offer some level of protection
- **Environment**: premises treated with pesticides with residual activity, destruction of refugia on property near barns, house…

Ticks found in North America
- Identification beyond the genus level is very difficult & and expert is often required
- Identification of nymphs & larva is even more difficult
- The following denotes some of the major features of important ticks in North America

Ixodidae (Hard ticks)

*Ixodes scapularis* (deer tick or black-legged tick)
- a 3-host tick that feeds on deer, rodents, rabbits & many other animals including dogs, cats, horses, birds & humans

Morphology
- Adults are small, inornate (not ornamented i.e. no white colour) no festoons, lack eyes, approximately 2-3 mm x 1-1.5 mm
  - Female - orange-brown, larger & has longer mouthparts than males
  - Male - dark brown
  - Nymphs are 1-2 mm x ~ 0.7 mm (about the size of a pin head)
  - Larvae are 0.5-0.6 x ~ 0.4-0.5 mm (six-legs)

Life cycle
- 3-host tick
- takes about 2 years to complete
- Adult females deposit eggs in the spring which hatch into larvae in ~ 30 days
- Larvae attach to host (mouse or vole) in late summer & feeds for 2-4 days then detaches to overwinter
- Larvae moult to nymphs the next spring & nymphs then attach to a host & feeds for 3-4 days
- Nymphs detach, moult to adults & adults then attach to new hosts in the later summer-fall where it mates, feeds & then detaches to lay eggs

**Pathology & Disease Transmission**
- Vector for the spirochaete *Borrelia burgdorferi*, the causative agent of Lyme disease which can occur in humans, dogs, cattle & horses
- White-footed deer mouse is the primary reservoir for *B. burgdorferi* & serves as the host for the larva & nymph stages
- Spirochaete can be transmitted both transstadially & transovarially
- Incidence of Lyme disease in humans (May-June) coincides with the activity of the nymphs that would have been infected the previous summer
- Small size allows the nymphs to go unnoticed while feeding

**Diagnosis**
- Dx to the genus level
  - made by examining the ventral surface of the tick for the presence of the anal groove which runs anterior to the anus
- Species level diagnosis requires an expert
Other *Ixodes* spp.

*Ixodes pacificus* is a vector for Lyme disease in the Pacific North-West & may be as cause of tick paralysis

- Various species of *Ixodes* ticks transmit bovine piroplasmosis & other diseases in Europe

*Rhipicephalus sanguineus* (Brown Dog Tick)
- Common ectoparasite of dogs & occasionally other mammals
- Widely distributed across most of the USA & parts of Canada (BC, ON, NS)

**Morphology**
- Inornate (no white colour), basis capitulum is hexagonally shaped in the dorsal view, festoons present
- Unfed adults may be 3-4.5 mm, but size is variable (engorged female may be 12 mm)

**Life cycle**
- 3-host tick taking as little as 63 days to complete
- Wide host range, but is particular to the dog
- Feeds on dogs during all 3 stages
**Pathology & Disease Transmission**
- Vector for:
  - *Babesia canis & Ehrlichia canis* (a rickettsia infecting mononuclear cells) in dogs
  - Rocky Mountain Spotted Fever (RMSF) (*Rickettsia rickettsii*) in parts of the USA
- Adept at invading kennels where high numbers can occur on dogs
- Professional exterminator may be required for control

**Diagnosis**
- All stages may be found on the dog

Festoons present, palpi not ridged.

- Hexagonal basis capitulum, festoons
- Distinct anal groove encircling posterior half of anus only
- Fore coxa deeply cleft

*Dermacentor spp. (Dermacentor variabilis, D. andersoni, D. albipictus)*

**Morphology**
- Rectangular basis capitulum, ornamented scutum, festoons present
- Approximately 4 mm
D. variabilis (American Dog Tick)
- Ectoparasite of dogs, horses, cattle, wildlife & humans
- Distributed over the east & west of the USA & parts of Canada

**Life cycle**
- 3-host tick & require 2 years to complete
- Larvae feed on small rodents, moult to nymphs & overwinter
- In spring, nymphs feed on small rodents, moult to adults & overwinter
- Adults feed on dogs & other large mammals the next spring

**Pathology & Disease Transmission**
- Vector for: *Cytauxzoon felis*, Rocky Mountain Spotted Fever (RMSF) & Tularemia
- Can cause tick paralysis

D. andersoni (Rocky Mountain Wood Tick)
- Ectoparasite of dogs, horses, cattle & humans in Western North America

**Life cycle**
- As above

**Pathology & Disease Transmission**
- Vector for: RMSF, tularemia & may transmit *Anaplasma marginale* (bovine anaplasmosis)
- Important cause of tick paralysis

D. albipictus
- Ectoparasite of moose, deer, elk, cattle & horses
- Widely distributed in North America

**Life cycle**
- 1-host tick
- Feeds only in winter, adult female drops off host to lay eggs in the spring

**Pathology**
- Can be significant pathogen by causing premature shedding of winter coat resulting in winter death loss
**Amblyomma americanum (Lone Star Tick)**
- distributed throughout Central & Eastern USA & its range is increasing

**Morphology**
- Mouthparts are longer than basis capitulum
- Reddish-brown with deep parallel grooves on scutum with a large pale iridescent spot at the posterior margin

**Life cycle**
- 3-host tick
- Larvae & nymphs feed on rodents, rabbits & birds
- Adults feed for 3-4 weeks on deer, cattle, sheep, horses & humans

**Pathology & Disease Transmission**
- Vector for: RMSF, tularemia & maybe Lyme Disease
- Commonly found on ears & flanks
- Female can ingest 1-2 ml of blood
- may cause tick paralysis

**Boophilus annulatus (Cattle Tick)**
- eradicaded from USA
- One-host tick & vector for Texas Cattle Fever (*Babesia bigemina*) & if encountered should be reported to authorities

**Argasidae (Soft Tick)**

**Argas persicus (Fowl Tick or Chicken Tick)**
- Ectoparasite of poultry found in Southern USA
- Female is ~8 mm & male is ~ 5 mm
- Feeds at night & hides in cracks & crevices during the day
- can cause severe anemia & a fatal flaccid paralysis in young chickens
**Otobius megnini (Spinose Ear Tick)**
- Ectoparasite of cattle & horses in Western & Southwestern USA & has been reported in BC

**Morphology**
- Larval & nymphal stages found in the ear canal of the host
- Nymphs have spines & body of second nymph is fiddle-shaped

**Life cycle**
- 1-host tick (rare for argasids)
- larvae board host & feed in ear canal for 7 days, moult to 1st nymphal stage which feeds & moults to 2nd nymphal stage in the ear canal (feeds for 2-6 months)
- 2nd nymph drops to ground to moult to adult stage that does not feed
- Adults mate & female deposits eggs intermittently for 6 months
- Eggs hatch in 2-3 weeks & larvae can survive 3 months without feeding

**Pathology**
- Considerable irritation to ear resulting in pain, head-tossing & ear-rubbing
- Secondary bacterial infections can occur as well as rupture of the eardrum & heavily infested animals can die.

---

**Mites (Acari)**

- Mites are a huge group of over 30,000 species, most of which are free living.
- Small portion are important ectoparasites of mammals & birds, where they feed on blood & lymph, skin debris or sebaceous excretions.

**General Characteristics**

- “Ticks are giant mites or mites are miniature ticks”
- Both share some morphological features with a few differences.

<table>
<thead>
<tr>
<th>Ticks</th>
<th>Mites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Macroscopic (large)</td>
<td>Microscopic (small) usually</td>
</tr>
<tr>
<td>Hypostome is toothed &amp; exposed</td>
<td>Hypostome is unarmed &amp; hidden</td>
</tr>
<tr>
<td>Haller’s organ present (functions as a humidity &amp; olfactory sensor &amp; aids in host finding)</td>
<td>Haller’s organ is absent</td>
</tr>
</tbody>
</table>
Life History

The life history of mites is similar to ticks:
- Egg, larvae (six-legs), nymph, adult
- may be between 1 & 3 nympha! instars
- Most ectoparasitic mites spend their entire lives in intimate contact with their hosts

Pathogenesis

- Acariasis (infestation with mites) but in many cases there is no obvious effect to the host (often considered to be part of the normal skin fauna)
- Mange - infestation causing severe dermatitis

Pathogenic mechanisms of mite infestation include:
- Direct damage to epidermis leading to inflammation
- Production of cutaneous hypersensitivity reactions
- Loss of blood & other fluids
- Transmission of pathogens

Mites of Veterinary Importance

Mange Mites (Suborder Astigmata)

Sarcoptes scabiei
Causative agent of Sarcoptic Mange in dogs, pigs, foxes, cattle, sheep, goats, horses, rabbits & humans

Morphology
- Microscopic (200-400µm)
- Round or globose shaped
- Posterior pair of legs do not extend beyond body margin
- Short legs with pretarsi having long unsegmented pedicels
**Life cycle**
- Entirely on the host & completed in ~17-21 days
- After copulation females burrow into skin feeding on cellular debris & laying eggs behind her
- Mites live ~ 4 weeks on the host & can only survive a few days off the host
- Highly contagious & transmission occurs through direct contact or fomites

**Pathogenesis**
- Tunneling & feeding activities of the mites cause irritation
- Hypersensitivity reactions to the mite secretory & excretory products

**Clinical signs**

**General**
- Intense pruritus
- Papulopustular eruptions, hemorrhagic crusts, hair loss, skin thickening & wrinkling

**Dogs (S. scabiei var canis)**
- Lesions on the lateral margins of ear, elbows, inguinal & head regions
- Self-mutilation & secondary bacterial infections common
- Infested dogs will usually die without treatment

**Pigs (S. scabiei var suis)**
- Lesions first appear on the head, progressing to the hind legs, then rest of body
- Reduced growth rate & lower feed efficiency

**Cattle (S. scabiei var bovis)**
- Most important mange mite of dairy cattle & confined beef herds
- Lesions occur where hair is thin (base of tail, brisket, inner thigh, scrotum & udder)
- Reportable disease

**Diagnosis**
- Clinical signs & history
- “pinnal-pedal reflex” (rub the dogs ear & it elicits a violent scratch response with the hindlimb)

**Multiple skin scrapings**
- Deep scrapings (should induce capillary hemorrhage)
- 10-20 scrapings may be required & demonstration of ONE mite is diagnostic
- Papular lesions on household members (humans infected with a transient scabies from contact with pets - infection is self-limiting)

**Control & Treatment**
- Treatment should be initiated if mange is suspected despite negative findings on scrapes
- All animals in household should be treated (S. scabiei has been reported on cats rarely)
Dogs

- Systemic: macrocyclic lactones (avermectins and milbemycins), Topical or spay (fipronil)
  - Topical (selamectin, imidocloprid + moxidectin)
- All dogs in contact with infested dog should be treated
- Acaricidal dips (e.g. 2% lime sulfur) every week until lesions resolve
- Environment should be treated (bedding, kennels, combs ...)

Livestock

- Treat entire herd with pesticide dips, repeat in 10-12 days
- Ivermectin & milbemycin

*Notoedres cati*

- causative agent of *Notoedric Mange* in cats (Head Mange or Feline Scabies) & may occasionally affect dogs or humans
- Morphology & life cycle similar to *Sarcoptes*

**Clinical signs**

- Intense pruritus
- Lesions characterized by hair loss, scales & crusts about the ears, head & neck initially

**Diagnosis**

- Clinical signs & skin scrapings

**Control & Treatment**

- treat all cats in household
- Acaricidal dips (as in canine scabies)
- Ivermectin, selamectin (be sure to use products approved for cats)

*Knemidocoptes spp.*

- Scaly-leg mite of chickens, turkeys & other birds
- Morphologically similar to *Sarcoptes* & tends to occur in small barnyard flocks with transmission by bird-bird contact (spreads slowly)

**Pathogenesis & Clinical signs**

- Mites burrow into skin of legs causing inflammation
- Results in scab formation & legs become swollen & encrusted & death can occur when birds lose mobility

**Diagnosis**

- Scrape scabs to find mites (loosen scabs first by soaking legs in warm vegetable oil)

**Control & Treatment**
- treat birds with pesticide dips or paints

Psoroptes spp.
- a non-burrowing skin mite that causes a serious form of mange called ‘Scab’ or Psoroptic Mange in sheep (eliminated from North America) & cattle from the South-West USA
- causes ear canker in rabbits & mild otic mange in goats & horses

Morphology
- Long legs with segmented pedicels

Pathogenesis & Clinical signs
Cattle
- Pruritus & scab formation due to mite feeding activities - causing self-mutilation

Rabbits
- Mites in external ears cause crusting of car canal
- can lead to rupture of tympanic membrane

Diagnosis
- Superficial skin scraping at margins of lesion & under crusts

Treatment & Control
- Pesticide dips, ivermectin (apply pesticide in ear of rabbits)

Chorioptes bovis
- Non-burrowing mange mite of cattle, horses, goats & sheep

Morphology
- Similar to Psoroptes except short unsegmented pedicels

Pathogenesis
- Common in dairy cows in winter
- Minor pathogen with lesions on neck, tail & lower legs which usually resolve in spring
- Irritation & alopecia can occur on hocks of horses (horses may act restless)

Treatment & Control
- Pesticides applied to affected areas when causing a problem

Otodectes cyanotis
- Ear mite (Otodectic Mange) of dogs, cats, foxes & occasionally humans
- Most common cause of otitis externa in cats
Life History
- Live on epidermal debris in the ear canal & skin
- Life cycle completed in 3 weeks
- Transmission by direct contact

Pathogenesis & Clinical signs
- Mechanical irritation & hypersensitivity reactions
- result in intense irritation, pruritus, scratching of ear & head shaking

Diagnosis
- Dark black-red exudate found in ear canal
- Otoscopic examination to visualize mite
- Microscopic examination of ear swab confirms mite… show the owner!

Treatment & Control
- Treat all animals on the premises
- Acaricides or mineral oil administered in the ear 3-4 weeks
- Otic suspensions of ivermectin, or topical treatment every 2 weeks for 3 treatments
- Systemic and topical products…
- Environment should be treated (bedding, kennels, combs …)

Prostigmatid Mites

Demodex spp.
- cause Demodectic Mange in dogs (D. canis, very common) & (D. cati, rare)

Morphology
- Microscopic (100-400 µm) & elongate (cigar-shaped)
- Stout legs ending in blunt claws (legs are vestigial)

Life History
- Embedded head-down in the hair follicle & sebaceous glands
- Unable to survive off host
- Life cycle completed in 18-24 days
- Prevalence is virtually 100% as mites are acquired at birth by direct contact & are considered normal inhabitants of the skin (usually non-pathogenic)

Pathogenesis
- Hereditary predisposition to demodectic mange (more common in purebreds - especially terriers, Great Dane, English Bulldog, Alaskan Malamute, Afghan)
- Mites are allowed to proliferate due to an immunosuppression of T- cells (reduced T-cell function) in affected dogs
- Mites may produce a factor that suppresses T-cell function
- Immunosuppression (e.g. corticosteroid therapy) may predispose dogs to demodecasis

**Clinical signs**

**Two forms of demodecasis:**

**Localized demodecasis**
- Focal areas of erythema & alopecia on head & neck & forelegs
- No secondary problems
- Most (90%) will resolve spontaneously

**Generalized demodecasis** (the other 10%)
- Onset in dogs due to some underlying factor
- Lesions spread from head to rest of body
- Generalized erythema, alopecia, crusting & scaling
- Secondary infections can occur resulting in oozing exudative lesions with severe crusting & pyoderma
- Severe cases are accompanied by a foul smelling putrid odor & are difficult to cure

**Diagnosis**

**Skin scraping**
- Squeeze skin to exude mite from the hair follicle then scrape skin
- Observing only a few mites is not diagnostic, but finding *many mites & many life stages indicative of demodecic mange*

**Trichogram**
- Examination of hair & roots
- Hair plucked from follicle is examined for mites

**Treatment & Control**
- Localized form good prognosis & likely will self cure in 6-8 weeks (with or without treatment)
- Generalized form requires supportive care & treatment of pyodermas with antibiotics
- Acaricidal dips (amitraz) do work especially when preceded by benzoyl peroxide shampoo (removes crusts & debris), this may be necessary on an intermittent basis for the rest of the dog’s life (with relapses)
- Extra-label use of macrocyclic lactones (avermectin & milbemycin) - long term & high doses
- Treatment can be costly, time consuming & requires commitment from owners
- Intact female dogs may worsen or relapse during estrus or pregnancy
  - Some recommend spaying to prevent above & for inheritable predisposition of disease
**Demodex gatoi**
- Shorter & blunted mite that is common cause of pruritus & alopecia in cats
- Resides on the surface of the skin of cats & is contagious (so all cats should be checked)
- Treat with pesticide dips

**Cheyletiella spp.**
- **Walking Dandruff** of dogs (*C. yaguri*), cats (*C. blakei*) & rabbits (*C. parasitovaorax*)

**MORPHOLOGY**
- Prominent hook-like accessory mouthparts (palpal claws)

**LIFE HISTORY**
- Surface dwelling parasites transmitted by direct contact & fomites
- Life cycle completed in 3 weeks with eggs attached to host hair
- Feed on surface debris & tissue fluids & can infest humans

**CLINICAL SIGNS**
- Pruritus & severe scaling on dorsal surface

**DIAGNOSIS**
- Examination of scales & hair coat with a hand lens for ‘walking dandruff’
- Superficial skin scraping
- Examination of scales collected with a flea comb
- Detection of mite eggs in fecal flotation

**TREATMENT & CONTROL**
- Sprays, shampoo with pyrethrins dogs
- Topical (fipronil, imidocloprid+moxidectin)
- Treat all animals in household & treat environment

**Trombiculids - Chiggers**

*Eutrombicula alfredugesi* & *Neotrombicula autumnalis*
- Larvae of chiggers are parasitic, while the nymphs & adults are free living
- Larvae are bright red to orange colour, 250-300 um & feed for several days
- Found on the feet, legs, head & ears of dogs & cats in late-summer or early fall & can cause an intense pruritus which can continue after the chigger is removed
Mesostigmatid Mites

*Derma*nyssus gallinae
- *Chicken Mite* is a blood-sucking mite of poultry in wood-framed houses
- Mites found on birds only when feeding (at night) otherwise hides in nests, roosts & crevices

**Life History**
- Females produce eggs after each meal
- Generation time of 7 days
- Adults can survive for ~ 8 months without feeding

**Pathogenesis & Clinical signs**
- Heavy infestations can cause severe anemia & can kill nestlings
- reduced weight gains & egg production
- Mites will readily attack humans

**Diagnosis**
- collect mites from birds at night or poultry house bedding
- Mites are nearly 1 mm & red in colour after feeding

**Treatment & Control**
- prevent transmission to clean houses
- apply pesticides to premises

*Ornithonyssus sylviarum*
- *Northern Fowl Mite* is the most important & common ectoparasite of the poultry industry

**Life History**
- Remains on bird throughout life
- Generation time of 5 days
- Mites can survive weeks off the host

**Pathogenesis & Clinical signs**
- Reduces egg production, weight gain & seminal fluid production in roosters
- Birds infested with ~ 50,000 mites lose 6% blood volume/day
- Mites readily bite humans

**Diagnosis**
- Mites are about 1mm & will be around the vent area of hens

**Treatment & Control**
- Prevent introduction into clean housing
- Pesticide treatment of environment & birds (spray or powder)
*Pneumonyssoides caninum*
- Parasite of the nasal sinuses of dogs that may cause chronic sneezing & epistaxis
- Infrequently encountered but are detected using nasal swabs or rhinoscopy
Insects - Class Insecta
- Insects comprise more than 3/4 million species, more than all other animal groups combined
- Occupy every ecological niche & are adapted to all life styles including parasitism
- Within the Class Insecta there are 29 orders & 3 orders are of veterinary importance
  - Diptera - the flies
  - Siphonaptera - the fleas
  - Phthiraptera - the lice

General Characteristics
- Distinguished from other arthropods by the presence of 3 pairs of legs in the adult
- Broad division of the body into 3 sections (head, thorax & abdomen)

Head
- Carries the main sensory organs
  - Single pair of antennae
  - Pair of compound eyes
  - Three simple eyes, the ocelli
  - Mouth parts (see below)
    - Mandibles (Jaws) used for cutting, tearing & crushing
    - Maxillae used in food handling
    - Labium also used for food handling
    - Additionally, an anterior labrum covers the mouth & a tongue-like hypopharynx arises from the floor of the mouth - these are not appendages but serve important feeding functions

Thorax
- Composed of three fused segments (prothorax, mesothorax & metathorax)
- Each segment bears a single pair of legs (composed of coxa, trochanter, femur, tibia, tarsus, pretarsus)
- Two pairs of wings may also articulate with the mesothorax & metathorax

Abdomen
- Composed of 9 - 11 segments
- Bears the external reproductive organs
Generalized Insect Morphology & Mouthparts
http://www.amnh.org/learn/biodiversity_counts/ident_help/Parts_Arthropods/grasshopper.htm
Lice (Phthiraptera)

- Lice are superbly adapted insect ectoparasites of birds & mammals
- Entire life spent on the host & are highly host-specific some even preferring specific anatomical regions

Divided into two groups:

The Anoplura - the sucking lice
The Mallophaga - the chewing lice

General Morphology

- Segmented body divided into head, thorax & abdomen
- All have three pairs of jointed legs, are dorsoventrally flattened, & are wingless
- Antennae are short & sensory organs are not well developed (eyes are vestigial or absent)

Anoplura (the sucking lice, are found only on placental mammals)
- Adults range from 0.5 - 8 mm in length
- **Head is narrower than thorax & elongated**
- Mouth parts highly modified, composed of 3 stylets which form a set of fine cutting structures
- Claws on the tarsus used to cling to hairs of the host, & the diameter of the claw is related to the diameter of the host’s hair shaft (host specificity)

Mallophaga (the chewing lice)
- Usually 2 - 3 mm in length
- **Heads are large, wider than thorax & rounded**
- Mandibulate mouthparts typical of chewing insects
**Life History**
- Hemimetabolus development (simple life style - juveniles morphologically similar to adults)
- Female lice cement 1-2 eggs (nits) per day to the hair shaft of the host & hatch in 1-2 weeks
- After hatching, nymphs feed & develop through 3-5 nymphal stages over the next 1-3 weeks; eventually moulting to adults (egg to adult can take 2-3 weeks in good conditions or 4-6 weeks)
- Lice only live 1-2 days off the host & are transferred from one host to another by **direct contact**

**Pathogenesis**
- **Pediculosis** (lice infestations) can have direct & indirect effects on the host

**Direct effects**
- Usually a function of the numbers of lice present (heavy infestations are often due to some underlying problem such as malnutrition)
- Pruritus, alopecia & self-wounding can result from heavy infestations
- Anemia can result from infestations of sucking lice
- Infestations can result in reduced vigour & weight loss

**Indirect effects**
- Vectors for: typhus & relapsing fever in humans
- Implicated in spreading pox virus in pigs, anaplasmosis in cattle, & some species may act as the intermediate host for *Dipylidium caninum*

**Diagnosis**
- Observation of lice on the skin of the host
- Observation of nits on the hairs
- Comb used to part hair is helpful as well as acetate tape strips
**Treatment & Control**
- Easily killed by a variety of treatments

**Dogs & Cats**
- Insectidal (e.g. carbaryl or permethrin containing) shampoo, dips, sprays or powders
  - fipronil, selamectin, imidacloprid, imidacloprid+moxidectin
- Treat all pets in household, bedding & grooming equipment should be disinfected.

**Livestock**
- Topical or systemic insecticides
  - Ivermectin, moxidectin, doramectin
- Lactating dairy cattle: carbaryl, eprinomectin

**Lice of Veterinary importance**
- Since lice are highly host specific, the host & site of infestation provide reliable information regarding identification

**Characteristics of specific Genera of Anoplura**

**Haematopinus**
- 4-5 mm in length
- Prominent angular process (ocular points) behind antennae
- Lateral margin of abdomen heavily sclerotized
- All tarsal claws are of equal size

**Linognathus**
- First pair of tarsal claws smaller than the second & third pairs
- Lateral margins of abdomen are not heavily sclerotized

**Solenopotes**
- Similar to Linognathus except that one row of setae (hairs) per abdominal segment
  (*Linognathus* has more than one row)

**Polypax**
- Found on rodents

**Pediculus, Phthirus**
- Found on humans…ick!

**Dogs**
- Chewing Lice: *Trichodectes canis, Heterodoxus spinigier*
- Sucking Lice: *Linognathus setosus*
Clinical signs
- Pruritus, scaling, crusts, matted coat, alopecia
- Severe infestations with Linognathus can produce anemia
- Trichodectes may transmit Dipylidium caninum

Cats
Chewing Lice: Felicola subrostratus is the only louse found on cats

Clinical signs
- Pruritus, scaling, crusts, matted coat, alopecia

Horses
Chewing Lice: Bovicola equi (Damalina equi)
Sucking Lice: Haematopinus equi

Clinical signs
- Pruritus, scaling, crusts, alopecia
- More common in winter months

Cattle
Chewing Lice: Bovicola bovis
Sucking Lice: Linognathus vituli, Haematopinus erysternus, Solenopotes capillatus

Clinical signs
- Pruritus, alopecia, dermatosis
- Sucking lice are found on the head, neck, withers, tail, groin, axila & ventrum
- Bovicola is found on neck, withers & tail
- Heavy infestations can cause anemia & weight loss & are usually due to poor management situations (therefore treating the lice will not solve the problem)

Pigs
Sucking Lice: Haematopinus suis

Clinical signs
- Pruritus, scaling, crusts & anemia (in heavy infestations)
- Commonly found around ears, axillae & groin
- Vector for swine pox virus

Sheep
Chewing Lice: Bovicola ovis
Sucking Lice: Linognathus ovillus, Linognathus pedalis

Clinical signs
- Pruritus & wool damage, loss of production
Infestation with *L. pedalis* (the foot louse) causes foot stamping & biting of the limb

**Poultry**
Chewing Lice: *Menopon gallinae, Menacanthus stramineus* (many others)

**Clinical signs**
- Lice are important ectoparasites on domestic birds
- Pruritus, scratching & feather damage
- reduced egg production & viability

**Humans**

Sucking Lice: *Pediculus humanus capitus, Pediculus humanus humanus, Phthrius pubis*

- Pets & livestock are **not** sources of human infestations: head louse, body louse & crab louse
- During heavy infestations fomites (such as bedding, towels & clothing) may act as means of transmission & lice may be recovered from the dog. However, the dog is never the culprit or reservoir of human lice!
Fleas - Siphonaptera

- Fleas are obligate blood sucking insects comprised of ~2500 species,
  - 95% of which are ectoparasites of mammals; the other 5% parasitize birds
- Feeding behaviour of fleas causes significant veterinary problems
  - Flea control products in the USA was worth well over $1 billion annually

General characteristics
Morphology
- Fleas are laterally compressed, wingless insects between 1 & 6 mm in length
- Range in colour from brown to black & are covered with backward projecting spines that may aid them in staying attached to the host
- Some species possess genal or pronotal combs (ctenidia) which are used in identification
- Caudal set of legs are adapted to jumping & some species can jump as high as 30 cm

Generalized Flea Morphology
http://www.lander.edu/rsfox/310CtenocephalidesLab.html
Mouthparts & Feeding
- Ventrally on the head a pair of maxillary stipes or lobes bears long maxillary palps
- Below these is the fascicle which is composed of fine grooved laciniae
- Between the grooved laciniae is the labrum-epipharynx
- When feeding, the laciniae puncture the host’s skin & the tip of the labrum-epipharynx enters the capillary allowing blood to flow up the food canal
- Feeding may take 2-10 minutes (females consume 2X as much blood as males)

Life History
- Consists of multiple episodes of temporary feeding on the host animal by adult fleas & developmental stages that are associated with animals that build nests or return to a lair, burrow or specific bedding place
- Holometabolus (egg-larva-pupa-adult) life cycle which can take ~12-14 days to complete under ideal temperature & relative humidity (RH), but can take 6-12 months to complete when conditions are sub-optimal
- Adults mate on the host (usually following a blood meal)
- After mating, females lay smooth pearly-white eggs (~0.5 mm) that fall off the host along with adult flea feces (which is partially digested host blood)
- Eggs & flea feces tend to accumulate where animals sleep or rest
- Eggs hatch in 1-10 days & the larvae feed on organic debris (hair, scales…) as well as flea feces
- Larvae are susceptible to desiccation & avoid direct sunlight & will move to the base of carpet fibres, in cracks between floor boards, under organic debris (grass, leaves, soil…)
- Larvae will moult twice (taking 5-11 days at 27°C & 80% RH) & the third stage larvae will transform into pupae within the cocoons constructed of silk (0.5 cm long)
- The cocoon is initially white, sticky & is typically coated by debris from the environment
- The pupal stage will last for 6-7 days & is quite resistant to desiccation
- Adults emerge from cocoons in response to environmental cues such as increased temperature, mechanical pressure & CO₂, but adults can remain quiescent within cocoon for up to 140 days.
- Following emergence, adult fleas use visual & thermal cues to locate hosts & jump on (they jump following light being interrupted & are oriented in the direction of the host by CO₂).
- Newly emerged adult fleas can survive between 10-65 days before finding a host (depending on temperature & RH).
- Upon acquiring a host, adult fleas begin feeding almost immediately.
- Most fleas are somewhat host-specific (feeding on one or few host species while others show no host specificity at all).

Pathogenesis
- Fleas inject hemorrhagic saliva that can cause severe irritation & cause a rash.
- Repeated feedings & high infestation can cause significant blood loss, iron deficiency anemia & even death!
- Inflammation & pruritus can lead to self-wounding.
- Vectors for bacteria (*Rickettsia typhi*, *Rickettsia felis*, *Bartonella henselae*, *Yersinia pestis*), helminths (cestodes: *Dipylidium caninum*, *Hymenolepis nana* & the non-pathogenic filarid nematode, *Acanthocheilonema* (*Dipetalonema*) *reconditum* (the one you can confuse with *Dirofilaria immitis* on a Knott’s test).

Flea-bite dermatitis
- Irritation & scratching in response to large numbers of feeding fleas

Flea-allergy dermatitis (FAD)
- Immunologic disease in which a hypersensitive state is produced in response to the injection of saliva
- Most common dermatologic disease in dogs & major cause of feline miliary dermatitis
- characterized by intense pruritus even if only a few fleas are feeding
- Areas of alopecia, pyotraumatic dermatitis (hot-spot), & crusted papules can develop
- Dogs develop immediate & delayed hypersensitivity reactions

Diagnosis
- Observe fleas or flea debris (flea dirt) on the skin of the animal
- Flea comb can aid in obtaining samples
- Place flea debris on wet-white paper towel & reddish-brown ring forms due to diffusion of digested blood
- Diagnosis of *Dipylidium caninum* indicates flea problem
- Intradermal testing for flea-bite dermatitis/flea allergy (FAD)

Control
- Successful control requires time, patience & effort - this can be frustrating
- Many products are available but the essential controls are:
  - **Host-targeted:** eliminate the resident population on the animal
  - **Environment:**
    - *Insecticides*, to eliminate the population that will re-infect the animal
    - *Mechanical means* (vacuuming, washing bedding…) to protect the animal from re-exposure from outside sources
- Adults comprise only 1% of the entire flea population, so control of immature stages in the environment is essential to any control program!

Host-Targeted
- Topical (e.g. dinotefuran, fipronil, imidacloprid, metaflumizone, selmectin …) & oral (e.g. nitenpyram & spinosad) products as adulticides either as single product or combinations as monthly control products which have dramatically changed flea control (for now?)
- Some topical products are effective against fleas & ticks but orals are ‘flea’ specific
- Some products are adulticide only or in combination with Insect Growth Regulators (e.g. methoprene, pyriproxyfen) or Insect Development Inhibitors (e.g. lufenuron)
- Considerations: speed of action, duration & spectrum of activity, route of administration, systemic versus topical

Environmental Control
- Vacuuming premises often (change bag & dispose of old bag properly) will remove some juveniles, but many will remain, therefore needs to be done regularly…
- Wash or change animals bedding, clean furniture…
- Spray premises with insecticides with residual activity
  - Larvae escape adulticidal treatments of premises by developing at the base of the carpet (no contact) & they require about 2.5 times as much insecticide/gram of body weight
  - lufenuron, methoprene, fenoxycarb have larvical activity
- Professional exterminator is a viable option…

**Identification of Fleas of Veterinary Importance**

*Ctenocephalides felis* - the cat flea
- Most important species on dogs & cats (93% of fleas on dogs & 99.8% of fleas on cats) & is the major cause of flea allergy dermatitis
- Ubiquitous & parasitizes a wide range of hosts including cats, dogs, cattle & humans
- Dx: Sloping elongated front of head with genal & pronotal comb & are about 2.5 mm long
- Life cycle completed in 12 - 14 days - 174 days depending on conditions
- Only a few fleas required to cause great misery to host (one bite can cause allergic reaction in sensitized host)

*Ctenocephalides canis* - the dog flea
- Closely related & morphologically similar to cat fleas, but relatively uncommon compared to C. felis, but can also cause FAD
- Dx: More rounded head than the cat flea but possesses both genal & pronotal combs

*Echidnophaga gallinacea* - the sticktight flea
- Flea of poultry but attacks all kinds of domestic animals including dogs, cats, rabbits, horses & humans
- Dx: Small fleas without genal or pronotal combs & have a sharply angled front of head
- Female fleas burrow into the skin & can remain attached for 2-6 weeks & the skin around the point of attachment can become ulcerated
- Eggs are laid in the ulceration or drop to the ground
- Sticktight fleas are significant parasites of poultry & can cause anemia, ocular ulcerations (which may result in blindness)
- In dogs, they are found in poorly haired areas of the ventrum, scrotum, interdigital areas & around the pinnae of the ears

*Pulex irritans* - the human flea
- Attacks a wide array of hosts including humans, dogs & swine
- Dx: Lacks genal & pronotal combs & has a smoothly rounded head with a single ocular bristle below the eye
- Breeds rapidly in pigsties & is most important species in farm areas

*Xenopsylla* - the rat flea

VPM-122 Protozoa Transmitted by Arthropod Vectors & Arthropod Parasites– Winter 2017 49
- Genus of rat fleas that attacks humans
- Dx: Lacks combs, has smoothly rounded head, a bristle in front of the eye and a vertical rod on the mesothorax (*Pulex* does not)
- Vector for *Yersinia pestis* (plague)

*Ceratophyllus niger* - the western chicken flea
- Common throughout Western Canada, USA & Alaska
- Dx: Genal comb is absent but has a pronotal comb & is about 4 mm long (much larger than sticktight flea)
- Does not attach permanently to its host like the sticktight flea
- Important flea of poultry but will attack dogs, cats & humans

![Flea Diagram](image)

*C. canis* (dog flea)  *E. gallinacea* (sticktight flea)  

*C. felis* (cat flea)  

*P. irritans* (human flea)  *Xenopsylla* (rat flea)  *C. niger* (chicken flea)
Flies - Diptera

- Diptera is one of the largest orders of the Insecta with over 120,000 described species
- Flies of veterinary importance are ectoparasites as adults or as larvae & rarely in both stages

General characteristics

- Adult flies range in size from 0.5-10 mm & exhibit considerable morphological diversity
- Body is divided into head, thorax & abdomen

Head
- Large, well developed & mobile
- Large compound eyes & a single pair of antennae of variable size & function
- Top of the head often bears three simple eyes or ocelli

Thorax
- Contains membranous wings along with the club-shaped halteres (flight stabilizers)
- 3 pairs of legs

Abdomen
- Vary in size & shape
- Can be modified in association with the genitalia

Mouthparts vary considerably in their form & function, but basically consist of the following:
- Paired maxillae
- Paired mandibles
- Labium with a terminal labella (or labellum)
- Hypopharynx
- Labrum

Life History
- Most flies are oviparous (lay small oval eggs in discrete batches) but a few species are ovoviparous (eggs hatch in the oviduct & the female deposits newly hatched larvae)
- All flies have a holometabolus life cycle: Egg-Larvae (3-5 stages)-Pupae-Adult
- Larvae (maggots) are soft, legless & segmented & in some species are parasitic (myiasis)
- Pupae has visible external appendages & develops within a cocoon or puparium
- Life cycle duration & the length of time adults live varies between species
Pathology
- Flies are considerable pathogens & can be organized into 3 groups depending on their lifestyle

Biting Flies
- Account for 50% of the annual losses in cattle production from all livestock pests in USA
- Blood feeders puncture the skin directly which results in pain & allergic reactions to saliva
- Acute blood loss (livestock have been killed by swarms of biting flies)
- Biological or mechanical vector for disease agents

Non-biting Flies
- Feed on secretions or scavenge at wounds or body orifices
- Cause annoyance & disturb host
- Often mechanical vectors for many pathogens

Myiasis Flies
- Lay eggs on tissues or in wounds of the host
- Larvae invade tissues & can cause significant damage to the host

All flies can also cause considerable disturbance to the host & in the case of biting flies & myiasis flies, dramatic escape responses resulting in self-injury

Large populations of flies can also cause death by suffocation after inhalation

Adult Flies of Veterinary Importance

Grouped into 3 sub-orders based on morphology & life history

Nematocera - Mosquitoes, Black Flies, Gnats & Sand Flies
Brachycera - Horse Flies & Deer Flies
Cyclorrhapha - House flies, Stable Flies & Horn Flies

Nematocera
- Small & slender flies with narrow wings & antennae composed of 6 elongated segment
- Mouthparts or proboscis is elongated & modified for feeding with labrum, mandibles, maxillae & hypopharynx (stylets) being thrust into the skin while the labium bends backwards (like a pool cue going through a players hand); saliva is pumped into the wound through the hypopharynx
- Generally breed in aquatic or semi-aquatic habitats & larvae are adapted to swimming
- Only females feed on blood
Mosquitoes - Family Culicidae
- Mosquitoes are found worldwide
- ~ 3000 species classified into 3 genera: *Aedes, Anopheles, Culex*

Morphology
- Long segmented antennae (14-15 segments)
- Very long proboscis & food is sucked up food canal by two muscular pumps
- Scales on the wings

Life History
- Female deposits eggs on surface of water or in an area that will be flooded
- Eggs hatch in less than 1 week
- Larvae moult 4 times within 3 weeks, becoming pupae
- Pupae are free swimming with a large cephalothorax
- After 2 weeks, adult emerges from the pupal case & crawl to nearby objects until wings expand & harden, then take flight
- Mosquitoes may overwinter as eggs, larvae or adults (species dependent)
- Females live for 2-3 weeks & require a blood meal to produce eggs

Pathology
- Annoyance, but bites can induce hypersensitivity
- Blood loss is generally trivial, but swarms can cause anemia & death
- Can have an impact on weight gains & milk production
- Disease vector for *Dirofilaria immitis* in dogs, Malaria & viral encephalitis, West Nile virus...

Control
- Eliminate breeding sites (standing water)
- Screen barns & cages etc.
- Keep animals indoors during peak activity (night, dawn & dusk)
- Repellents (e.g. DEET), but require frequent application
Black Flies - Family Simulidae
- Over 1500 species but only the genus *Simulium* is of veterinary importance
- *Simulium* feed on the blood of cattle, horses, poultry & just about all animals including humans

**Morphology**
- Adults are black, grey or yellow-brown, 1-5 mm in length with stout bodies & a humped thorax
- Antenna are shorter than other nematocera with 11 segments
- Proboscis is shorter than mosquitoes & imbibe from accumulating pool of blood (i.e. they don’t suck but man do they bite hard!)

**Life History**
- Females deposit eggs on submerged stones or vegetation in highly oxygenated water (i.e. flowing)
- Eggs hatch in 6-12 days & larvae attach themselves to stones using posterior hooks & by spinning silken strands they attach to rocks
- Some species overwinter as larvae
- Pupation takes place in an underwater cocoon firmly attached to the rocks or other objects
- Adults emerge from the pupal case & are carried to the surface in a bubble of air & can fly immediately
- Time of development is species dependent & water temperature
- Longevity of adults can range from 2-3 weeks up to ~85 days
- Mating occurs soon after adults emerge & female requires a blood meal for eggs to develop

**Pathology**
- Female has a very painful bite that can cause considerable disturbance even in low numbers
- Hypersensitivity can result to toxins in fly saliva
- Massive attack in cattle can cause death due to anemia or reaction to the toxin, characterized by petechial hemorrhage & edema of the larynx & abdomen
- Vector for: *Leucocytozoon* to poultry & *Onchocerca* to cattle

**Control**
- Shelter animals during peak activity (tend to swarm in daylight hours)
  - 3-walled, roofed shed provides darkness & protection
- Keep animals pastured away from running water
- Pesticide or repellent application using sprays, dips, back rubbers etc. or light smudge pots

Gnats - Family Ceratopogonidae
- Small blood sucking ectoparasites also known as no-see-ums
- *Culicoides, Leptoconops, Forcipomyia* are important genera

**Morphology**
- Small, less than 2 mm in length with long filamentous antennae (14-15 segments)
Life History
- Eggs are deposited in damp marshy ground
- Larvae burrow into surface of the substrate where they pass through 4 instars & most species overwinter as larvae
- After pupation, adults will rarely fly more than 500 m from their breeding site & feed in humid weather usually at sunset or night

Pathology
- Painful bite & large numbers can be a serious annoyance to livestock
- *Culicoides* can cause Sweet Itch in horses (a pruritic dermatitis & alopecia due to hypersensitivity reaction to saliva) as can *Simulium* (Black Fly)
- Vector for: Bluetongue virus in cattle & sheep, viral encephalitis to horses & *Onchocerca* to cattle & horses

Control
- Avoid activity period
- Eliminate habitat (drain marshes, increase slope of sewage lagoons & drainage ditches to reduce mud)

Brachycera
- Only one veterinary important family, the Tabanidae

Horse Flies & Deer Flies - Family Tabanidae
- Only 3 veterinary important genera - *Tabanus* (Horse Flies), *Hematopota* & *Chrysops*

Morphology
- Large stout bodied flies up to the size of a humming bird! (25 mm)
- Short stout antennae consist of 3 segments
- Have short strong mouthparts composed of a pair of saw-like mandibles, narrow toothed maxillae, stout labrum & hypopharynx & short labium possessing a labellum
- When feeding, the labellum is retracted & the mandibles, maxillae & labrum penetrate the skin
- Mandibles move in a scissor-like action & saliva (anticoagulant) is pumped into the wound
- Blood is sponged up into the food canal (formed by the labrum & hypopharynx)
- After feeding, the mouthparts are withdrawn & the labellum closes trapping a film of blood between them which is important in transmitting pathogens

Life History
- Eggs are deposited in wet mud near rivers or lakes, or in pockets of moist soil
- Eggs hatch in 4-7 days & larvae quickly moult
- Larvae are aquatic, semi-aquatic or terrestrial
- Require several months to years to pass through 6-13 instars & pupation requires 2-3 weeks
- Most species complete development in 10-42 weeks
- Adults live 2-4 weeks & produce only one generation (Univoltine)
- Adults are active in the daytime along ‘fly ways’ & tend to wait in moist shady areas for a host to pass by & are attracted by urine, sweat, CO₂, body odours etc.

**Pathology**
- Vicious biters & very painful creating considerable annoyance & disturbance
- Peak losses of blood of 200 ml/day in cattle have been reported
- Each fly can take up to 0.6 ml/meal during a blood meal
- Large wounds can become secondarily infected or attract other flies

**Mechanical vectors for:**
- Anaplasmosis in cattle
- Anthrax
- Tularemia
- Equine Infectious Anemia virus
- Hog cholera virus
- Vesicular stomatitis in cattle

**Control**
- Avoid fly ways during daytime or stable during peak hours
- Repellents can be used effectively
- Tabanids are difficult to kill with insecticides
- Draining mosquito habitat, may increase Tabanid habitat…ugh

**Cyclorrhapha**
- There are a number of important families in this sub-order that are of veterinary importance as adults & as larvae (myiasis)
- The adult flies or importance are in the family Muscidae & Hippoboscidae

**House Flies & Face Flies - Family Muscidae - Genus Musca**
- 60 species of *Musca*, with *Musca domestica* (house fly) & *Musca autumnalis* (face fly) of particular importance

**Morphology**
- 6-8 mm in length with a grey thorax with 4 dark longitudinal stripes
- Mandibles & maxillae are absent & the labella are sponging organs used to ‘mop-up’ liquid when feeding

**Life History**
- Eggs are laid in fresh manure (*M. autumnalis*) or older manure piles, garbage or rotting organic matter (*M. domestica*)
- Larvae (maggots) go through 3 instars within a week & enter the ground to pupate
- Pupation takes 3-5 days & adults emerge & are receptive to mating after 36 hours
- Egg to adult takes 7-14 days depending on environmental conditions
- 10-12 generations can occur in a summer (Multivoltine)
- *M. domestica* is associated with livestock indoors, while *M. autumnalis* is associated with pasture animals

**Pathology**
- Nuisance & annoyance
- *M. autumnalis* feeds on lacrimal, nasal & salivary excretions & congregates in large numbers on the faces of animals & acts as a vector for *Moraxella bovis* (Pink Eye) & *Thelazia* (ocular nematode of cattle & horses)
- *M. domestica* can mechanically transport protozoan cysts & serves as the intermediate host for *Draschia megastoma* & *Habronema muscae*

**Control**
- Insecticide application to premises, fly breeding sites & animals
- Fly baits, strips, etc. may also be used
- Good sanitation is important (especially in control of *M. domestica*)

**Stables Flies - Family Muscidae - Genus Stomoxys**
- Contains 18 species with *Stomoxys calcitrans* is the most important

**Morphology**
- Resembles the house fly but has a long pointed proboscis which is used to inflict a painful bite

**Life History**
- Similar to house flies as they lay eggs in rotting organic material & manure in & around farm buildings (not fresh manure)
- Can be found on animals outside, but will follow animals inside to feed
- Active by day & found on hosts only when attempting to feed

**Pathology**
- Inflicts a painful bite & is a very annoying & destructive pest of livestock
- Loss of blood & disturbance can result in 10-15% reduction of body weight & decreased milk production
- Intermediate host for *Habronema majus* & may be vector for Anthrax & other bacterial & viral diseases

**Control**
- Eliminate breeding sites (rotting material etc.) & application of insecticides to premises or animals
Horn Flies - Family Muscidae- Genus Haematobia
- *Haematobium irritans* is an economically important parasite of cattle (& horses to a lesser extent)

**Morphology**
- About half the size of the stable fly with a relatively shorter proboscis

**Life History**
- Adults remain on cattle during the warmer parts of the year taking periodic blood meals (obligate permanent ectoparasite)
- When cattle defecate, the horn flies swarm to the droppings to lay eggs then return to the host
- Development is similar to other muscidid flies

**Pathology**
- Inflict a painful bite that can cause annoyance & result in reduced weight gains & milk production
- Permanent attachment of flies with periodic feeding can cause significant blood loss, & the wounds can attract other flies
- Vector for *Stephanofilaria stilesi* (nematode of cattle)

**Control**
- Insecticides applied to cattle by back rubbers, dusts, oilers or insecticide impregnated ear tags are very effective because adults remain on the host (resistance has been demonstrated)
  - eprinomectin has good efficacy
- Effective control which has been shown to result in a 4-1 return

Keds - Family Hippoboscidae
- *Melophagus ovinus* is a wingless blood-sucking continuous ectoparasite of sheep & goats

**Morphology**
- Brown in colour, 5-8 mm in length & dorsoventrally flattened
- Wingless & tick-like in appearance with strong claws to help them cling to wool or hair

**Life History**
- Female deposits 1 fully developed larvae at a time
  - egg hatches inside her body & is nourished through 3 larval stages
- Deposited larvae immediately pupates (female glues it to wool)
  - emerges as an adult in 19-24 days
- Adult females live 4 months & produce 12-15 larvae
- Transmission by direct contact (ewe to lamb is important)
- Keds survive up to 4 days off the host
**Pathology**
- Cause irritation to skin making sheep restless so they do not feed well & may lose condition
- Wool loss & discolouration (from blood) results in wool being downgraded

**Control**
- Insecticides, ivermectin
- Shearing can reduce numbers

**Myiasis**
- Myiasis is the infestation of the tissues or organs of animals by the larval stages of dipterous flies
- Fly larvae feed directly on necrotic or living tissue of the host & myiasis can be classified as follows:

**Obligatory myiasis**
- A living host is required to complete development (will not survive without a living host)

**Facultative myiasis**
- Living host tissue is not required to complete development

**Accidental myiasis**
- Rare chance events of myiasis (i.e. accidental ingestion of fly eggs)

**General characteristics**
- Myiasis is caused by cyclorrhaphous dipteran larvae

**Morphology of the larvae**
- Larva (maggot) is usually pointed anteriorly, conical & divided into 12 segments (head, 3 thoracic segments, 8 abdominal segments)
- Cuticle is soft & unscelorotized, but may be covered in scales or spines
- Larva is legless, but may have protuberances that aid in locomotion
- A pair of mouth-hooks protrudes from the atrial cavity (atrium) which is a pre-oral cavity anterior to the functional mouth
- A pair of anterior spiracles located just behind the head & a pair of posterior spiracles on the 12th segment (the posterior spiracles are used in identification)
**Life History**
- Eggs of myiasis flies are deposited directly on an animal or on vegetation where they are likely to be picked up by a passing host
- Eggs usually hatch within 24 hours & 3 larval stages follow in which feeding occurs
- After the 3rd stage larva completes its feeding it leaves the host & finds a suitable place to pupate (usually burrows into the ground)
- After pupation, adults emerge & may or may not feed before mating & depositing eggs

**Pathology**
- Effects of myiasis can vary depending on the numbers of larvae, species of fly, and the site of infestation
- General signs include irritation, discomfort, pruritus, weight loss, reduced fertility
- Heavy infestations can result in severe tissue damage, hemorrhage, anaphylaxis, toxemia, secondary bacterial infections & death will result if not treated

**Traumatic Myiasis**
- Involves open wounds

**Furuncular Myiasis**
- Involves boil-like lesions

**Creeping Myiasis**
- Path of the larva can be traced beneath the skin

**Sanguinivorous Myiasis**
- Rare blood-sucking form
**Bots & Warbles - Family Oestridae**

- All flies in the family Oestridae are obligate parasites & highly host specific
- Larvae have posterior spiracular plates containing numerous small pores & the adults have primitive or non-functional mouthparts & are short-lived

**Oestrus**
- Small genus containing 5 species of which *Oestrus ovis*, the sheep nasal bot fly, is of importance in North America

**Morphology**
- Immature larvae are white (1 mm) & become yellow/brown as they mature, growing to 20 mm
- Adults are grey, 10-12 mm in length, with small black spots on the abdomen & have reduced (knob-like) mouthparts

**Life History**
- Females are oviparous & deposit larvae (up to 25 at a time) in or on nostrils of sheep (goats)
- Larvae crawl into the nasal passages & sinuses where they attach to the mucus membranes, feed on mucus & desquamated cells & develop
- Mature to 3rd stage larvae & enter the nasal cavities where they crawl or are sneezed out of nose
- Upon reaching the ground they pupate
- Development can take 25-35 days during the warmer months, but 1st stage larvae will overwinter in the sinus cavities of the host until the spring

**Pathology**
- Irritation & inflammation caused by the larvae can result in sticky mucoid nasal discharge, sneezing, nose rubbing or head shaking
- Larvae positing females cause annoyance & sheep bunch together with heads towards the centre, or sheep will run in panic which results in less grazing time & reduced weight gain

**Treatment**
- Ivermectin

**Gasterophilus**
- Obligate parasites of horses & donkeys with *Gasterophilus nasalis* (Throat Bot fly), *Gasterophilus intestinalis* (Horse Bot Fly) & *Gasterophilus hemorrhoidalis* (Nose Bot Fly) being important in North America

**Morphology**
- Adults are 11-15 mm in length & resemble a honeybee with a long curved ovipositor & non-functional mouthparts
**Life History**
- Eggs are attached to the hairs of the host in a particular body region
  - *G. intestinalis* on the hairs of the forelegs
  - *G. nasalis* on hairs of the intermandibular skin
  - *G. hemorrhoidalis* on the hairs of the lips
- Eggs hatch spontaneously (*G. nasalis*) or in response to moisture (*G. hemorrhoidalis*) or temperature (*G. intestinalis*)
- Larvae enter the mouth & migrate through the tongue & interdental spaces where they feed on tissue exudates & develop
- The 2nd stage larvae enter the stomach & develop to 3rd stage larvae where they attach to the stomach or duodenum mucosa by the mouth hooks (each species in a different location)
- After attachment, the bots develop for up to 12 months then detach & are passed in the feces (*G. hemorrhoidalis* attaches to the wall of the rectum for several days before being passed in the feces)
- Larvae pupate in the soil & adults emerge 2 weeks - 2 months later

**Horse Bots (Gasterophilus):** A - eggs hair attachment; B - oviposition sites & attachment of larvae of the various species; C, D, E - mature larvae of (C) *G. nasalis*, (D) *G. intestinalis* & (E) *G. haemorrhoidalis*.
(Source - USDA)
Pathology
- Light infestations have little effect
- Larvae migration can cause irritation & secondary bacterial infections (pus pockets in the mouth) as well as oral lesions
- Larvae cause a chronic gastritis when attached to the stomach or intestine, but there is little evidence that this results in clinical disease
- Bots may be associated with reduced weight gain, disruption of digestion, ulceration & stomach rupture
- Humans may become infested with larvae (migrate through oral tissues but do not complete the life cycle) by ‘horse kissing’ (rare)

Treatment & Control
- Washing legs with warm water will induce hatching of *G. intestinalis* & wash away the larvae
- Topical treatments of pesticides to kill eggs/larvae
-Traditionally, systemic pesticides to kill larvae (use periodically throughout the season) with final application 1 month before killing frost
- Common treatments now macrolides (ivermectin, moxidectin)

Hypoderma
- Also called warbles, heel flies or cattle grubs
- *Hypoderma lineatum* - Common Cattle Grub occurs in USA & parts of Canada
- *Hypoderma bovis* - Northern Cattle Grub occurs in Northern USA & Canada

Morphology
- Adults are 13-15 mm in length & bee-like in appearance & lack mouthparts

Life History
- Adult females deposit eggs on the hairs of the lower legs of cattle (rarely of horses)
- After the eggs hatch, larvae penetrate the skin directly or through the hair follicle & migrate through the tissues taking 2-4 months to reach the submucosa of the esophagus (*H. lineatum*) or dorsal tissues surrounding the spine (*H. bovis*)
- Larvae develop for another 3 months then migrate to the dorsal subcutaneous tissues where they cause a small swelling (warble) & cut air holes in the hide (their dorsal spiracles apposed to the air hole)
- After molting twice over the next 2 months, larvae enlarge the air holes & exit, dropping to the ground to pupate
- Warble of *H. lineatum* become apparent between January & February, while warbles of *H. bovis* appear in March
Cattle Grubs (*Hypoderma*): A & B - hair attachment of Northern Cattle grub (A) & Common Cattle Grub (B); C - routes followed by the larvae of cattle grubs from the legs to the back of the cow; D - mature grub in warble. (Source - USDA)

**Pathology**
- Warbles result in carcasses being trimmed & downgraded
- Damage to the hides limits their value as leather
- Ovipositing females result in dramatic avoidance behaviour in cattle called gadding which can result in self injury
- Anaphylactic shock can result from warble being crushed during removal

**Treatment & Control**
- Systemic ivermectin, doramectin, moxidectin
- Organophosphates to kill larvae early in migration
- Treat animals after adult fly activity ceases & before larvae reach sensitive tissues (correct time varies with geographic region)
- Treating when larvae have reached tissues around esophagus & spinal cord can result in serious tissue & nerve damage (results in bloat, ataxia or paralysis)
- Manual removal of grubs involves injecting 1 ml of 3% hydrogen peroxide into air hole & grub will emerge in about 15 seconds (piercing grub during procedure can result in fatal anaphylactic shock)
**Cuterebra**
- Rodent or Rabbit Bot Fly that occasionally infests cats & dogs

**Morphology**
- Adults are rarely seen & resemble a bumblebee with vestigial mouthparts

**Life History**
- Flies lay eggs along a rabbit run or near burrow
- Eggs hatch instantly when animals run by & larvae attach
- Larvae enter host through natural body openings & migrate through the tissues locating the subdermally
- Mature larvae leave skin & pupate in the soil
- Cats & dogs are infested when trying to stick their heads down a rabbit burrow entrance (August-October)

**Pathology**
- Warbles usually found in cervical subcutaneous connective tissues in cats & dogs
- Rarely, larvae may migrate into other tissues with fatal results if the brain is involved

**Treatment**
- Surgical removal of the bot & wound treatment (often misdiagnosed as a tumour)

**Blowflies - Family Caliphoridae**
- All blowflies are facultative to obligate parasites as adult flies lay eggs in living flesh or rotting carrion depending on the species

**General characteristics**
- All adult blowflies are a shiny metallic colour (black, blue, green or copper)
- Eggs are laid in wounded, infected or fecal soiled skin
- Larvae pass through 3 instars while feeding on host tissues causing cutaneous or traumatic myiasis
- When mature, larvae migrate away from the site of myiasis & drop to the ground where they pupate, then emerge as adults
- Infested animals suffer intense irritation, anorexia, loss in fleece value & death will occur if untreated

**Cochliomyia**
- Screw worms are green to violet-green blowflies with 3 longitudinal stripes on the thorax
- the primary screw worm *Cochliomyia hominivorax* & the secondary screw worm *Cochliomyia macellaria* are important causes of myiasis in cattle, horses, sheep, goats, pigs, dogs & humans
**Life History**
- Female *C. hominovorax* flies deposit eggs in fresh uninfected wounds of all kinds (even as small as a tick bite!)
- *C. macellaria* deposits eggs in carrion, infected wounds or other myiasis (necrotic tissues) & is often found with *C. hominovorax*

**Pathology**
- Untreated *C. hominovorax* infestations are extremely pathogenic & will rapidly cause death

**Control & Treatment**
- Sterile Male Release Program has eliminated the screw worm from North America
- To treat, apply topical insecticides & prevent further fly infestations of wound
  - Ivermectin, doramectin can also be used to prevent infestation

**Lucilla, Phormia, Protophormia, Calliphora - Strike Flies**
- Blow Flies are facultative parasites that can cause a condition known as "strike" in livestock (sheep & cattle) & sometimes other domestic animals

**Lucilla - Green Bottle Fly**
- Metallic green flies that deposit eggs in areas soiled by urine & feces (perianal & inner thigh regions)
- are the most important cause of primary strike in sheep & are attracted to animals with fleece rot (*Lucilla cuprina* kills 3 million sheep each year in Australia)

**Phormia, Protophormia - Black Blow Fly**
- Metallic blue to black in colour & are important in northerly habitats
- lay eggs in necrotic tissues associated with wounds & are common causes of livestock myiasis in Northern USA & Canada

**Calliphora - Blue Bottle Fly**
- Adults are metallic blue in colour
- are attracted to feces & urine but act as secondary or tertiary agents of myiasis (i.e. deposit eggs in a current myiasis wound)

**Control & Treatment**
- Sanitation & avoidance of surgical treatment during fly season
- Control of enteric pathogens that cause diarrhea (e.g. coccidiosis in lambs) & removal of soiled wool
- Apply pesticides to animals with shearing wounds
- Insecticides should be applied to infested livestock
- Small animals should have hair clipped, maggots removed & topical pesticide to prevent further infestation
- Ivermectin & moxidectin are not effective treatments for strike one infestation has taken place