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**
- the 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
- Species include *Trypanosoma brucei* and *T. congolense* which are 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
- Species include *Trypanosoma cruzi* which is 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 um long with a pointed posterior end and are found in circulating blood of the vertebrate host
- kinetoplast located near the posterior end and the flagellum is long and runs out the anterior end
- undulating membrane (formed from the flagellum running through the body) is narrow

**Amastigote**
- spheroid, 1.5 - 4.0 um, lack flagella
- develop within muscle and other tissues in clusters

**Epimastigote**
- flagellated with the kinetoplast located between the nucleus and the anterior end and are found in the posterior portion of a triatomine bug’s gut

**Life Cycle**
- when the triatomine bug feeds on a vertebrate it defecates
- the feces may contain trypomastigotes (called metacyclic trypomastigotes in the hind gut of the bug)
- trypomastigotes gain entry into the host body through the bite wound, or more commonly through scratched skin or mucus membranes when the vertebrate host rubs the bite wound
- trypomastigotes first enter the blood stream and then enter cells of the spleen, liver, lymphatics and cardiac, smooth and skeletal muscle
- once inside the cell they lose their flagella and transform into a amastigote and reproduce by repeated longitudinal binary fission
- amastigotes are released when the host cell lysis, they may transform back into trypomastigotes and may either enter new cells locally or into general circulation
- Feeding triatomine bugs may then ingest trypomastigotes with their blood meal
- trypomastigotes then enter the posterior portion of the triatomine bugs gut and reproduce by binary fission as epimastigotes
- metacyclic trypomastigotes are found in the rectum of the bug 8 - 10 days post blood
meal and can now infect a vertebrate host

**Life cycle of Trypanosoma cruzi in humans**

**Epidemiology**
- Distribution:
  - Central & South America and Mexico (infests 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** - megasymphdromes (megacolon, megaesophagus) can result from destruction of autonomic ganglia (therefore destroys tos 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 and 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. are transmitted by sandflies of the genus *Phlebotomus* in the Eastern Hemisphere and *Lutzomyia* in the Western Hemisphere

there are several clinical forms of leishmaniasis in humans, dogs, rodents and wild mammals
- visceral leishmaniasis
- cutaneous leishmaniasis
- muco-cutaneous leishmaniasis

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

Taxonomy of *Leishmania* is confusing as all species are morphologically identical
Infections in Foxhounds in North America were found to be the result of the *Leishmania donovani* species complex

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

**Amastigote** - spheroid, lack flagella, 2.5 - 5.0 um and are found in the vertebrate hosts tissue

**Life cycle (Leishmania donovani)**
- *Leishmania* promastigotes are inoculated into the skin of the vertebrate in the saliva of the feeding vector
- inside the vertebrate host the *Leishmania* organisms are engulfed by macrophages where they multiply rapidly by longitudinal binary fission, destroying the macrophage
- after escaping the dead macrophage, the amastigotes are engulfed by new macrophages and the cycle continues, eventually leading to severe damage of the reticuloendothelial system of the host
- if the vector ingests the amastigote along with a blood meal they become lodged in the midgut of the insect and multiply by binary fission
- amastigotes transform into promastigotes and can soon be found in the esophagus, pharynx and buccal cavity where they can infect a new host during the next blood meal

**Epidemiology**
- *Leishmania* is endemic in the Mediterranean (including Southern France, Spain and Italy), Asia, South & Central America
- *Leishmania* has been reported in Foxhounds in Oklahoma, Texas, Ohio, New York and Ontario with a seroprevalence of 41% in a New York colony
  - the method of transmission in this case is unknown
  - both *vertical* (transplacental/transmammary) or *horizontal* (contact with blood) have been proposed
  - 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 cells from the 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 & not specific*, both visceral & cutaneous forms of Leishmaniasis can occur (alone or in combination)
- epistaxis, seizures, hair loss, abnormal nail growth, skin lesions (ulcers), swollen limbs & joints
- chronic wasting, kidney failure, liver failure
- death

**Diagnosis**
- amastigotes are detected on 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
  - Q-PCR for detection of parasite

**Control & Treatment**
- treatment is difficult & current **drugs do not cure** the disease
- drugs are used in an attempt to reduce the clinical signs of disease
- drugs commonly used are, Meglumine Antimoniate with Allopurinol, Aminosidine & Amphotericin B
- all drugs require a 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

The piroplasms intracellular apicomplexan parasites of blood cells in vertebrates that are transmitted by a tick vector

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 & a cause of occasional disease in dogs in the USA
- vector is the 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 tick, *Dermacentor variabilis* has acted as the vector under experimental conditions

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, but 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 and 2 - 4 µm in diameter (size is species dependent)
- blue cytoplasm with red chromatin mass when stained with Wright-Geimsa

**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 are transmitted to the vertebrate host as a tick feeds (the longer the vector is attached, the greater the chance of sporozoite transmission)
  - *Babesia* sporozoites then infect erythrocytes, become trophozoites and multiply asexually by binary fission
  - *Theileria & Cytauxzoon* sporozoites first invade a lymphocyte & then undergo schizogony (form schizonts) and merozoites are released from lysed lymphocytes which then go on to infect erythrocytes
  - merozoites released from ruptured erythrocytes infect new erythrocytes and 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
Life cycle of *Babesia microti*

**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

*Cytauxzoon 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 resulting 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, splenomegaly, icterus, dehydration
- Cyauxzoon is a rapidly progressing fatal disease in cats

Diagnosis

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

Cyauxzoon felis
- history & clinical signs
- observation of organism 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
Malarias
Malaria is caused by a number of Apicomplexan parasites in the genera *Plasmodium*, *Heamoproteus* & *Leucocytozoon*

**Causative agent & Host Range**

*Plasmodium* spp.
- causes malaria in humans & non-human primates, rodents, birds & reptiles
- transmitted to mammals by anopheline mosquito & to birds by culicine mosquito
- between 300 - 500 million people are infected with malaria each year
- between 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)
- are parasites 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 are transmitted to the vertebrate host when the black fly feeds
- sporozoites enter cells in 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 and is widespread in adult turkeys in the Southern USA
- *L. caulleryi* infections have only been reported in South Carolina (although common in Japan & South-East Asia)

**Pathogenesis**
- destruction of infected host cells resulting 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 c.s. appear 10 - 19 days post exposure
- older birds - chronic infections with low mortality, but can become listless & thin
  - decreased egg production, egg weight & hatchability are associated with infections
  - recovered birds harbour the parasite in their 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
- new 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 has been approved by the FDA for control of infections in turkeys
Veterinary Ectoparasitology – Arthropods Parasites

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

Within the phylum Arthropoda, there are 3 separate classes 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 are 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 the body into clusters of 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 so arthropods undergo periodic shedding of the exoskeleton (moulting or ecdysis)
- stages between moults are called stadia (or stages), while the from the arthropod is in is termed instar (e.g. larval instar)

**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

The 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

The juvenile stage 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)
  - the anterior cephalothorax
  - bears mouth parts (chelicerae, palps & hypostome)
  - the 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
The 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
- the hypostome is then thrust into the wound & its teeth help 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 into the wound & are sucked up
- while feeding, ticks secrete considerable amount of saliva containing anticoagulants &
  to dispose of surplus water 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
The life cycle can 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)
- a six-legged larva emerges from the egg & climbs onto the tips of vegetation where they ‘quest’ for a host
  - ticks detect the approach of the host through sensory cues
    - CO₂ using chemoreceptors in their Haller’s organ 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 moults to an eight-legged nymph
  - 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) and often must “sit & wait” for the host
- Feeding & generation cycles are often synchronized with periods of suitable temperature & humidity

Tick Host Life Cycles

Argasidae

- In contrast to most ixodid ticks, argasid ticks live in close proximity to their hosts
- they spend less time finding & frequent feeding is possible
- most argasid ticks have a **multi-host life cycle**
  - adults mate away from the host & feeding occurs several times
  - the female lays small batches of eggs (400-500) after each feeding
  - the larvae feed once then moult to the first stage nymph
  - there are 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**
- blood loss in heavy infestations can be considerable (200 lbs of blood in large hosts has been reported)
- the loss of blood, pain & swelling from the bite wounds, secondary infections & absorption of toxins causes ill thrift known as “tick worry”

**Dermatosis**
- inflammation, swelling, ulceration & itching can result from components of tick’s saliva & mouthparts that remain in the wound

**Paralysis (Tick Toxicosis)**
- 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 and 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 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 animals skin as possible (forceps or fingers may be used) and exert steady, gentle traction

Dogs & cats
- **Host-targeted:** Topical products (selamectin & 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
- tick identification beyond the genus level is very difficult & and expert is often required
- tick 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 (no white colour) no festoons, lack eyes, approximately 2-3 mm x 1-1.5 mm
  - female is orange-brown, larger & has longer mouthparts that the male
  - male is 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

**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 the late summer & feeds for 2-4 days when it 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
- the white-footed deer mouse is the principal reservoir for *B. burgdorferi* & serves as the host for the larva & nymph stages
- the spirochaete can be transmitted both transstadially & transovarilly
- the incidence of Lyme disease in humans (May-June) coincides with the activity of the nymphs that would have been infected the previous summer
- do to the small size of the nymph it can easily feed unnoticed

**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

In Europe, various species of *Ixodes* ticks transmit bovine piroplasmosis & other diseases

*Rhipicephalus sanguineus* (Brown Dog Tick)
- a 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
- also a vector for Rocky Mountain Spotted Fever (RMSF) (*Rickettsia rickettsii*) in parts of the USA
- adept at invading kennels where high numbers can occur on dogs
- a professional exterminator may be required for control

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

- hexagonal basis capitulum, festoons
- distinct anal groove encircling posterior half of anus only
- fore coxa deeply cleft

Festoons present, palpi not ridged.

![Image of Rhipicephalus sanguineus](image_url)
Dermacentor spp. (*Dermacentor variabilis, D. andersoni, D. albipictus*)

**Morphology**
- rectangular basis capitulum, ornamented scutum, festoons present
- approximately 4 mm

![Morphology Diagram]

*D. variabilis* (American Dog Tick)
- an ectoparasite of dogs, horses, cattle, wildlife & humans
- distributed over the east & west of the USA & parts of Canada

**Life cycle**
- 3-host tick & requires 2 years to complete
- larvae feed on small rodents, moult to nymphs & overwinter
- in the 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 *Cyttauxzoon felis*, Rocky Mountain Spotted Fever (RMSF) & Tularemia
- can cause tick paralysis

*D. andersoni* (Rocky Mountain Wood Tick)
- an 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 the 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
- tick commonly found on ears & flanks
- each female can ingest 1-2 ml of blood
- may cause tick paralysis
**Boophilus annulatus** (Cattle Tick)
- eradicated 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 & moult 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)

The mites are a huge group of over 30,000 species, most of which are free living. A small portion are important ectoparasites of mammals and birds, where they feed on blood and lymph, skin debris or sebaceous excretions.

General Characteristics

Ticks are giant mites or mites are miniature ticks. Therefore they both have the same morphological features with a few differences.

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

Life History

The life history of mites is similar to ticks:

- Egg, 6-legged larvae, nymph, adult
- There may be between 1 & 3 nymphal instars
- Most ectoparasitic mites spend their entire lives in intimate contact with their hosts

Pathogenesis

Infestation with mites is called acariasis and in many cases there is no obvious effect to the host (often considered to be part of the normal skin fauna)

Infestation can also result in severe dermatitis called mange

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 (200-400um)
- round -globose shaped; posterior pair of legs do not extend beyond body margin
- short legs with pretarsi having long unsegmented pedicels

**Life cycle**
- takes place entirely on the host & completed in ~17-21 days
- following copulation the female burrows into the skin feeding on cellular debris & laying eggs behind her
- mites live about 4 weeks on the host & only survive a few days off the host
- highly contagious & transmission occurs through direct contact or fomites

**Pathogenesis**
- tunnelling & 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
- the pinna-femoral reflex (rub the dogs ear and 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 can become 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) and 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
- acarcidal 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
- black exudate found in ear canal
- otoscopic examination to visualize mite
- microscopic examination of ear swab

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 (100-400um) & elongate (cigar-shaped)
- stout legs ending in blunt claws (legs are vestigial)

Life History
- spend life 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 demodecosis

Clinical signs

Two forms of demodecosis:

Localized demodecosis
- focal areas of erythema & alopecia on head & neck & forelegs
- no secondary problems
- most (90%) will resolve spontaneously

Generalized demodecosis (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 demodectic mange

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

**Treatment & Control**
- localized form has good prognosis & likely will self cure in 6-8 weeks (with or without acaricidal 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 and for inheritable predisposition of disease.

*D. 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 & haircoat 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 alfreddugesi & Neotrombicula autumnalis*
- the 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**

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

**Life History**
- females produce eggs after each meal
- generation time of 7 days
- adults can survive for up to 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 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, which is more than all other animal groups combined
- occupy every ecological niche and are adapted to all life styles including parasitism

General Characteristics
- distinguished from other arthropods by the presence of 3 pairs of legs in the adult
- have a broad division of the tagmata into 3 sections

Head
carries the main sensory organs
- single pair of antennae
- pair of compound eyes
- three simple eyes, the ocelli
- the mouth parts (see below)

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
- is composed of 9 - 11 segments
- bears the external reproductive organs

The mouthparts of the insects are highly specialized in relation to their diet and are composed of three pairs of appendages:

Mandibles (Jaws)
- are used for cutting, tearing & crushing

Maxillae
- used in food handling

Labium
- also used for food handling

In addition an anterior labrum covers the mouth and a tongue-like hypopharynx arises from the floor of the mouth - these are not appendages but serve important feeding functions
Within the Class Insecta there are 29 orders & 3 orders are of veterinary importance

**Diptera - the flies**
**Siphonaptera - the fleas**
**Phthiraptera - the lice**

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
- spend their entire life 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 are highly modified, composed of 3 stylets which form a set of fine cutting structures
- “crab-like” 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)
- are usually 2 - 3 mm in length
- heads are large, wider than thorax & rounded
- have mandibulate mouthparts typical of chewing insects
**Life History**
- hemimetabolus development (simple life style - juveniles morphologically similar to adults)
- adult female lice cement 1 - 2 eggs (nits) per day to the hair shaft of the host & these 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**
- lice infestations, called **pediculosis**, can have direct & indirect effects on the host

**Direct effects**
- effect of lice is usually a function of their numbers (& 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**
- lice can act as vectors for typhus & relapsing fever in humans
- they have been 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
- lice are 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
- because 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

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
- the 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.

The feeding behaviour of fleas causes significant veterinary problems. In 1995 the market for flea control products in the USA was worth over $1 billion.

General characteristics

**Morphology**
- Fleas are laterally compressed, wingless insects between 1 & 6 mm in length.
- They range in colour from brown to black and 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.

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Generalized Flea Morphology
http://www.lander.edu/rsfox/310CtenocephalidesLab.html
Mouthparts & Feeding  
- ventrally on the head a pair of maxillary stipes or lobes bear 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)

Generalized Flea Mouthparts  
http://www.lander.edu/rsfox/310CtenocephalidesLab.html

Life History  
- the life history of the flea is associated with temporary feeding episodes of adult fleas on the host animal & developmental stages that are connected (or associated) with animals that build nests or return to a lair, burrow or specific bedding place  
- fleas have a holometabolus life history (egg-larva-pupa-adult) 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 in length) that fall off the host along with adult flea feces (which is partially digested host blood)  
- the eggs & feces tend to accumulate where animals sleep or rest  
- eggs hatch in 1 - 10 days & the larvae feed on organic debris (hair, scales etc.) as well as flea feces  
- larvae are susceptible to dessication & avoid direct sunlight and 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 dessication
- 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 12 - 62 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 hosts species while others show no host specificity at all)

Generalized Flea Life Cycle
http://nz.merial.com/pet_owners/cats/disease/ec_seasonal.html
**Pathogenesis**
- Fleas inject a hemorrhagic saliva that can cause severe irritation and 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 filarial 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-infest 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, selemectin …) & 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 furnititure…
- 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, fenoxy carb have larvacidal activity
- professional exterminator is a viable option…

**Identification of Fleas of Veterinary Importance**

*Ctenocephalides felis* - the cat flea
- the 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
- have a 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
- has 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
- 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
- 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**
- Genus of rat fleas that attacks humans
- 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)

**Ceratophyllum niger - the western chicken flea**
- common throughout Western Canada, USA & Alaska
- 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

![Images of fleas](image)

- *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.

The flies of veterinary importance are ectoparasites as adults or as larvae, but are rarely ectoparasites in both stages.

**General characteristics**

Adult flies range in size from 0.5 mm to 10 mm in length and exhibit considerable morphological diversity.

The body is divided into head, thorax and abdomen.

**Head**
- large, well developed and mobile
- carries large compound eyes and a single pair of antennae of variable size & function
- top of the head often bears three simple eyes or ocelli

**Thorax**
- the membranous wings arise from the thorax along with the club-shaped halteres (which are used to stabilize the fly during flight)
- 3 pairs of legs

**Abdomen**
- can 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

The larvae (maggots) are soft, legless & segmented & in some species are parasitic (myiasis)
The pupae has visible external appendages & develops within a cocoon or puparium
The duration of the life cycle and the length of time adults live vary between species

Pathology

Flies are considerable pathogens & can be organized into 3 groups depending on their lifestyle

**Biting Flies**
- in the USA, account for 50% of the annual losses in cattle production from all livestock pests
- blood feeders that puncture the skin directly which can result in pain & allergic reactions to saliva
- acute blood loss (livestock have been killed by swarms of biting flies)
- can act as biological or mechanical vector for disease

**Non-biting Flies**
- feed on secretions or scavenge at wounds or body orifices
- cause annoyance & disturb host
- are 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 segments
- 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 player's 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 & there are ~ 3000 species divided primarily 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 breath through a siphon
- 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 (DEET), but require frequent application

Black Flies - Family Simulidae

There are over 1500 species but only the genus *Simulium* is of veterinary importance. *Simulium* feed on the blood of cattle, horses, sheep, goats, poultry & many other 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!)

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
- transmit Leucocytozoon to poultry and Onchocerca to cattle

Control
- shelter animals during peak activity (tend to swarm in daylight hours), a 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)
- can transmit 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 and labrum penetrate the skin
- the mandibles move across each other in a scissor-like action & saliva (containing 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
- larvae 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 (up to 0.6 ml/meal) creating considerable annoyance & disturbance
- peak losses of blood of 200 ml/day in cattle have been reported
- 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 flyways during daytime or stable during peak hours
- repellents can be used effectively
- Tabanids are difficult to kill with insecticides
- draining mosquito habitat, my increase Tabanid habitat

**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 continuos 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)
- after the larva is deposited it 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 loose condition
- wool loss & discoloration (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**
- the larva (maggot) is usually pointed anteriorly, conical & divided into 12 segments (head, 3 thoracic segments, 8 abdominal segments)
- cuticle is soft & unscelcorotized, but may be covered in scales or spines
- the larva is legless, but may have protuberances that aid in locomotion
- a pair of mouth-hooks protrude from the atrial cavity (atrium) which is a pre-oral cavity anterior to the functional mouth
- there are a pair of anterior spiracles just behind the head & a pair of posterior spiracles on the 12th segment (the posterior spiracles are used in identification)
Life History
- the 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
- the 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
- the path of the larva can be traced beneath the skin

Sanguinivorous Myiasis
- a rare blood-sucking form
Bots & Warbles - Family Oestridae

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

**Oestrus**
- a 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 in length & become yellow or 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 oviviparous & deposit larvae (up to 25 at a time) in or on the 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 out or are sneezed out of the 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”

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**
- if untreated *C. hominovorax* infestation is 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**
- these 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