

Entomology and Acarology

Lecture-1

Arthropods have probably descended from ancestors which also gave origin to soft annelid worms (e.g. Earthworm), but arthropods have developed outer covering of chitin, which forms an exoskeleton in which whole body is enclosed. This chitinous covering not only covers external surface, but also pass through mouth into anterior part of alimentary canal called stomodaeum and also pass through posterior part of alimentary canal called proctodaeum. Both of these arise as invaginations from the exterior into the body.

Exoskeleton is present in form of chitinous plates called sclerites.

Dorsal sclerite = Tergum, ventral sclerite = Sternum, Lateral sclerites = Pleurons.

Tergum, Sternum & Pleurons is united with more flexible portions of chitinous exoskeleton.

With passage of time arthropods grows and becomes too big for its chitinous covering and so periodically this is cast off and a new exoskeleton is formed. Each casting of the exoskeleton is called ECDYSIS. Different stages separated by ecdysis are called STADIA and form of insect during each stadium is called INSTAR.

Arthropods are segmented animals and these segments of arthropods are fused in groups.

The anterior six segments are fused to form head. The process of formation of head is called cephalization.

1st segment = a pair of eyes.

2nd segment = a pair of antennae

3rd segment = no appendage

4th segment = a pair of mandible

5th segment = a pair of maxillae

6th segment = a pair of 2nd maxillae.

Eyes: Compound eyes- Dichoptic (apart from midline) & Holoptic (located near to midline). Simple eyes or Ocelli on dorsum on vertex.

Antennae: are tactile organs, provided with sensory hairs and apparently sensitive to air currents. They also have olfactory pits which possibly perceives odour. It can take various forms.

Antenna is many jointed or have only few segments-

Clubbed at tip

Pectinate (flat) at tip

Antenna bears lateral hairs.

If hairs are numerous, it is termed as plumose antennae e.g. Male mosquitoes.

If hairs are less, it is termed as pilose antennae e.g. Female mosquitoes.

Mouthparts of insects

1. Biting and chewing = Cockroach
2. Piercing and sucking = Mosquitoes, horse fly, stable fly, tsetse
3. Lapping up fluid food = *Musca*, blow flies

Diptera: Mouth parts of insects

1. Attached to clypeus is Labrum upper lip which overhangs the mouth parts.
2. On its inner surface, it bears a small membranous structure epipharynx which bears taste organs, together with upper lip it is called LABRUM- EPIPHARYNX.
3. A pair of mandibles --- strong, serrated cutting organ.
4. Hypopharynx – a membranous structure which form base of food canal. It contains salivary duct which bring saliva to the prestomum tube.
5. A pair of Ist maxillae = Strong, cutting organs.
6. Labium (lower lip) modified to 2nd maxillae.

Nematocera and Brachycera = Piercing is with help of mandibles and first maxillae

Cyclorrhapha = Mandible and maxillae are absent (generally non-functional or lapping type mouthparts).

In some cyclorrhaphan flies, piercing is performed by special arrangement of teeth at distal end of 2nd maxillae e.g. *Stomoxys*

In all cases, fused second maxillae form a large lower lip which bears mouthparts.

Maxillae also possess jointed palps – which have sensory function.

Thorax

Prothorax: bears one pair of legs

Mesothorax: bears one pair of legs and one pair of membranous wings.

Metathorax: bears one pair of legs and halteres or balancers (modified wings in Dipteran insects)

Wings: Double membranous structure which would collapse if not supported by ramification network of trachea. The tracheal tubes are sandwiched between membrane structures and are brown in colour. When these tubes are examined, it gives appearance of veins, so they are called wing veins. They never carry blood, but are hard due to chitinous lining and give support to wings. It helps in classification and respiration.

Second pair of wings in dipteran insect located on metathorax and is modified into balancers/halteres.

Halters have three parts, membranous disc like structure, stalk & cushion like structure

Legs: have five segments i.e. coxa, trochanter, femur, tibia and tarsus. Coxa of each pair articulates with ventral side of each segment of thorax. Tarsus consists of five pieces, last one have one pair of claws. A pair of pads (pulvilli) occurs below the claw. The last piece of tarsus expands into a median lobe between the claws called empodium or arolium. Legs are used for walking, climbing and leaping.

Respiratory system

- System of branching tubes (trachea) open through spiracles/stigmata on the sides of the body.
- Spiral thickenings are secreted by chitogenous cells.
- They end inside insect in air sacs with very delicate wall.
- There may be pair of spiracles on each segment, generally reduced, none in head and prothorax. The spiracles may be bordered by thick rim of chitin which bears bristles and they open into vestibule which contains a valve controlled by muscles.
- Respiratory movements are produced by muscular contraction and elastic distension.

Digestive System

- Crop is present in most dipteran.
- Mosquitoes – crop has three thin bags.

Gizzard is present in insects that eat solid food. It is provided with a set of teeth. Salivary glands are paired and its duct open in hypopharynx.

In Cyclorrhaphan, insect's proventriculus is compact, spherical structure which functions as a valve.

In acarina mid-gut has several diverticula which are blind sacs and are capable of great distension.

Vascular system: situated dorsally and consists an aorta and general body cavity or haemocoel.

Aorta carries blood to head.

When axillary muscle contracts, blood enters in the compartments of heart through pair of ostia.

As compartments contract blood is pushed forward to head and haemocoel.

Heart is a tubular structure surrounded by pericardial cell, lumen divided into compartments by valves.

Blood is viscid fluid and contains few cells.

Nervous system – Circum-oesophageal commissure with ganglia and double ventral chain of ganglia from which nerves are given off.

Reproductive system: 2 testes, vas deferens, vesicular seminal is present.

Development:

Egg temperature Young one.

humidity →

In some cases, young one hatch from egg resembles the adult. It differs from adult only in size and minor features (ticks, lice).

In some other cases there is marked difference-Larva, pupa and adult are seen (dipteran flies)

During development the insect undergoes a variable degree of changes or Metamorphosis.

Subclass – Apterygota -- No metamorphosis / or slight one (**Ametabola**)

 Pterygota - greater or lesser degree of metamorphosis

When metamorphosis is complete (Holometabolous)-

- form that leaves the egg is called larva
- It feeds and grows and eventually becomes a quiescent phase called pupa
- Inside pupa imago/adult is formed.

When metamorphosis is simple (Hemimetabolous)-

- Form that leaves the egg is like that of adult is called nymph
- Nymph merely grows, casting its skin several times to become the imago

The larvae of complete metamorphosis can take various forms.

1. Polypod larva: has well marked head, a thorax of three segments, each of which bears a pair of clawed legs, and an abdomen of 10 segments which bears six pair of fleshy hooked legs called prolegs e.g. Larvae of butterfly.
2. Oligopod larva: have a well-marked head, three pairs of thoracic legs but no abdominal legs e.g. Larvae of beetles.
3. Protopod larva: larva having imperfectly segmented abdomen e.g. Hymenopteran insects.
4. Apodous larva / Maggot: Have no legs, either on thorax or abdomen, head is also reduced e.g. Larvae of house fly, larvae of Dipteran flies.

Pupa also can take three forms:

Free or Exarate pupa: Wings and legs can be seen externally and they are free from rest of the body e.g. Pupa of beetles.

Obtectate pupa: Legs and wings are bound down to the body by moulting fluid, but they can be usually seen externally e.g. Pupa of Brachyceran and Nematocerans insects.

Coarctate pupa: It is enclosed in the skin of the last larval phase called puparium which hardens slowly and adult insect inside cannot be seen e.g. Pupa of housefly.

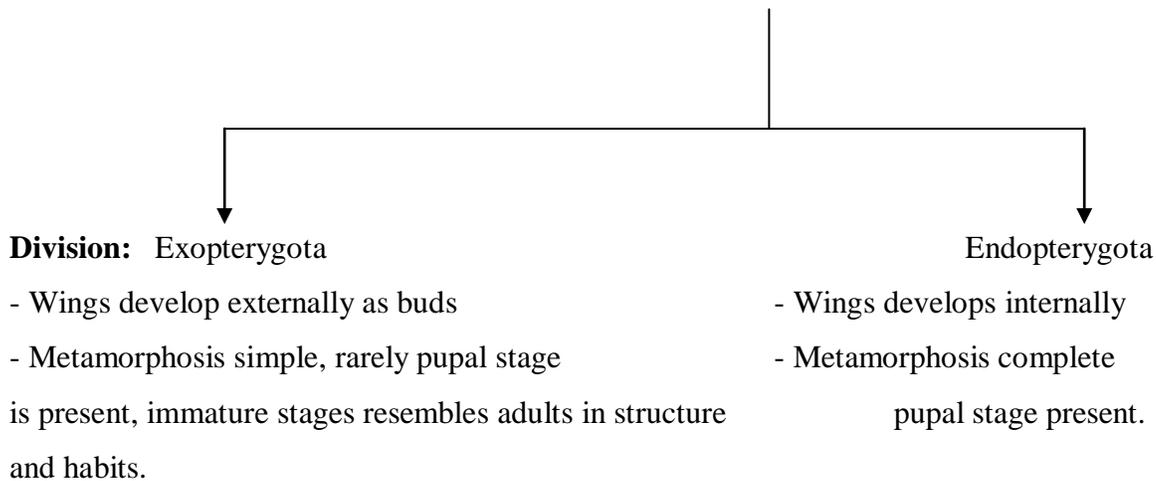
Subclass

Apterygota

- Wingless insects
- Metamorphosis absent /slight
- One or more pairs of abdominal appendages other than genitalia.
- Not of veterinary Importance

Pterygota

- Winged insects
- Metamorphosis varied, rarely absent or slight
- No appendage.
- Have veterinary importance.



Lecture-2

ORDER – DIPTERA

- Mouthparts are adapted for piercing and sucking / lapping type.
- Mesothorax usually large and fused to small pro- and metathorax.
- have only a single pair of functional membranous wings (Mesothoracic pair)
- Number of veins in the wings is reduced.
- Metathoracic pair is modified to halteres / balancers.
- Tarsi usually have five joints.
- Metamorphosis is usually complete, larvae being apodous with reduced head.
- The pupa may be coarctate enclosed in puparium or obtectate.

Order- Diptera divided into three suborders-

| NEMATOCERA | BRACHYCERA | CYCLORRHAPHA |
|--|--|--|
| <ul style="list-style-type: none"> - Antennae of adults are longer than head and thorax > 8 segments (except first two near to head all are alike) - No arista. - Larvae are aquatic have well developed head and mandible bites horizontally. - Pupa Obtectate. - Mandibles and Maxillae present (First pair) | <ul style="list-style-type: none"> - Antennae shorter than the head & thorax < 6 segments, only 1st 3 segments being often present, last segment is annulated. Arista may be present but when it is present it is terminal. - larva has retractile head, usually incomplete, mandible bites vertically. Pupa obtectate Mandibles and maxillae (First pair) present. | <ul style="list-style-type: none"> - Antennae have only three segments Arista present, usually on the dorsal side. - Larva has vestigial head. Pupa coarctate. Mandible and maxillae absent |

Suborder: Nematocera

Family – Culicidae (Mosquitoes)

- Small spherical head and long legs.
- Antennae have 14-15 segments, Plumose in male and pilose in female.
- Proboscis long and slender
- Thorax is wedge shaped, with broad end dorsal, Abdomen is elongate
- Wings long, narrow and folded flat over abdomen during rest. It bears leaf like scales along the margins and on the veins.

Subfamilies:

- Anopheline (Genus: *Anopheles*) and culicine (Genus: *Culex* and *Aedes*)
- There are over 2500 different species of mosquitoes throughout the world.

Life Cycle:

- Eggs are laid in water (*Culex* & *Anopheles*). *Aedes* lay their eggs on damp soil / floating vegetable material

Egg rafts = *Culex*

Aedes & *Anopheles* laid singly

(Anterior side towards water)

(float)

- Larva – well developed head, distinct thorax and abdomen

Head bears eyes, antennae and several hairs

Mouthparts are masticatory and surrounded by brushes which produce current

Unsegmented thorax bears feathered hairs

Abdomen is segmented and also hairy

The stigmata from which trachea passes through the whole body are situated on fused 8 and 9th segment, 10th segment bears feathered hairs and gills.

(Gills well developed in *Aedes* that feed in the bottom of water)

- ❖ *Anopheles* larva has palmate hairs (*Anopheles* larva lies against surface). Siphon tube is absent.
- ❖ Culicine larva has a siphon tube arising at dorsal aspect of 8th and 9th segments and surrounds stigmata. At apex it has chitinous valve (Larva hang down against water surface). Palmate hairs are absent.

(larvae moult four times)

Anal gill well developed in *Aedes*.

- Pupa/tumblers: Pupa has rounded body- head, thorax and elongate abdomen. Pupa is obtectate.
 - Through delicate cuticle wings and appendages of adult can be seen.
 - From dorsal aspect of thorax and attached to lateral stigmata, there arise a pair of tubes or respiratory trumpets, through which it breaths.
 - Pupa is active like larva.

Anopheles - Respiratory trumpets- Short and broad

Culex - Long and tubular

Short and truncated

- Abdomen has eight segments, with terminal pair of paddle or fins.

Adults: *Anopheles*

Culex

Female

Palps = Proboscis

Palps very short

Antennae pilose

Antennae pilose

Male

clubbed palps = Proboscis

Palp = Proboscis, not clubbed

Antennae plumose

Antennae plumose

Rest with abdomen directed away
from resting surface i.e. Proboscis

Rest with abdomen pointing towards

& abdomen is in straight line

resting surface i.e. Proboscis and abdomen at an angle
gives humped back appearance

Biology

- Development time differs according to species.
- Average time in favourable climate is 10 days.
- Cold period may extend larval stage
- Variation in the seasonal prevalence of different species mainly due to temp. and rainfall factor.
- Adults fly fair distances (kilometers) from breeding grounds, especially anophelines.
- They are attracted by warmth radiating from host.

- They transport in all means by road, water and air.
- *Aedes* are strong fliers & generally do not enter dwellings and prefers mammals.
- *Aedes* bite in day time.
- *Culex* have painful bite and these are weak fliers prefer birds.
- Bites are painful as cause minor local allergic reactions.

Importance

- They act as vector for many pathogens

DH of *Plasmodium* ---- man---- female *Anopheles*

Birds --- *Culex, Aedes*

IH of filarid nematodes

Wuchereria bancrofti = *Culex, Aedes, Mansonia*

Brugia malayi = *Mansonia, Anopheles*

Dirofilaria immitis = *Anopheles, Culex, Mansonia*

Spirochaete = *Borrelia anserina* = *Aedes*

Viral diseases

| | | | |
|---|-------------------|---------------------|--|
| Rift valley fever | man | Southern Africa | = all species. |
| Yellow fever | man | Africa | = <i>Aedes</i> species. |
| Dengue fever | man | Africa | = <i>Aedes</i> species |
| Japanese B-encephalitis | man | Japan | = <i>Aedes</i> and <i>Culex</i> |
| Eastern & western equine encephalitis | man, horse, birds | West of Mississippi | = <i>Aedes, Mansonia,</i> even <i>Anopheles</i> |
| Eastern & western Venezuelan encephalitis | | | |
| St. Louis encephalitis: | Man | | |
| Tularemia (<i>Pasteurella tularensis</i>) | animals | | <i>Anopheles & Aedes</i> from rats. |

Control

Depends upon habits of species, topography and climate of area, social status and economic status of population

I. Elimination or reduction of their breeding ground

- by drainage of pools.
- by destruction of larvae – by changing water level.
- Removal of vegetation from banks, surface of streams and ponds

II. Destruction of larvae - Drainage, changing water level

- by fishes - *Gambusia*
- by poisons – Paris green mixed with kerosene, OP – chlorinated hydrocarbons , DDT, Fenthion

III. Destruction of adult mosquitoes.

- Trapping – light or animal traps
- Insecticides

IV. Protection against mosquitoes

- Mosquito proofing of buildings, airy rooms with white walls which attract less number of mosquitoes.
- Tightly screened doors and windows.
- Mosquito nets.
- Clothing: head wets, gloves, high boots.
- Repellants – Indalone, Benzyl benzoate, oil of citronella.

Lecture-3

Family – Ceratopogonidae

Genus - *Culicoides*

- minute insects called biting midges, punkies, no-see-ums, gnats
- short proboscis adapted for sucking, mandibles like scissors.
- Thorax is humped over head
- Long antennae, Plumose = male, Pilose = female
- Wings have hairs, spotted, and anterior veins are stouter than posterior
- Wings are folded flat over abdomen at rest.
- Size 1-3 mm, Predatory in adult stage, dark flies.

Life cycle: Eggs are laid in single row in decaying vegetable material, in tree holes on aquatic plants or in manure piles.

Larva is vermiform, smooth bodied, have a small head with mandibular mouthparts, 3 thoracic and abdominal segments, terminal segment bears locomotory spines. At post end they have retractile anal gills. Apneustic (lack spiracles), it also respire through skin. When disturbed, they swim about actively with serpentine movement. They are white in colour.

Pupa- brown, inactive, obtectate pupa has two long, respiratory trumpets on the sides of mesothorax, 9th abdominal segment end in two spines with which pupa anchors itself in or at the surface of shallow water or in crevices in manure heaps, rotting vegetables. Whole pupa is covered with spines and tubercles.

Biology- Nocturnal

Importance – Annoyance due to bite in man and animals

- Vectors for protozoa and filarid nematodes.

| Host | Type of Nematode | Country | <i>Culicoides</i> Species |
|--------|------------------------------|---------|---------------------------------------|
| Man | <i>Dipetalonema perstans</i> | Africa | <i>C. Grahami</i> - <i>C. austeni</i> |
| | <i>D. streptocava</i> | Africa | -do- |
| Horse | <i>Onchocerca cervicalis</i> | Britain | <i>C. nubeculosus</i> |
| Cattle | <i>O. gibsoni</i> | Malaya | <i>C. pungens</i> |

- Blue tongue of sheep, Asia, Africa, N. America
- African horse sickness

C. robertsi causes allergic dermatitis of horses in Queensland. It is recurring seasonal dermatitis of individual horses and ponies. There is loss of hair on the dorsal part of body e.g. withers, base of tail, lesions may be exacerbated by self-inflicted damage.

Transmit protozoan – *Haemoproteus* and *Leucocytozoan* of wild and domestic birds.

Control – Screens treated with repellants and insecticides prevent entry.

- Control of breeding places – drainage
- Malathion, Parathion
- Spraying of walls with residual insecticide

Family Psychodidae (Genus- *Phlebotomus*)

- Sandflies /owl midges/ small flies over 5mm long
- Body and wings are hairy. Wings are lancet shape
- Legs are long, rarely short.
- Wings are held roof like over the abdomen during rest.
- Mouthparts are short or medium sized.
- Antennae long, 16 segments, beaded appearance, covered with hairs.
- Palps are recurved and hairy

L.C. - Eggs are laid in moist, dark places egg in rock crevices b/t stones 40-60 egg laid at a time. The eggs are elongate 0.4mm in length, first translucent then turns into dark coloured, covered with adhesive substance.

Larva: A sluggish, segmented, caterpillar like larva hatches out

Large head, dentate mandibles, grayish white body.

Each abdominal segment bears a transverse row of toothed spines.

Terminal segment has long (inner pair) and short (caudal) of bristles.

Larva feed on faeces of Lizard's, bats and other animals on dried larva.

Pupa: has triangular head with long antennal sheaths and curved abdomen small spines are present on the sides of thorax and abdomen.

Adult: As above

Biology - Flies are active at night only and hide during the day in dark corners. Weak fliers and are blood suckers.

Importance:

- Actual wound is a sharp, painless incision with dermal hemorrhage from injured capillaries.
- Itching, rose coloured papule surrounded by erythematous area 10 to 20mm
- In extreme cases there may be oedema, enlarged regional lymph node, fever.

Transmit:

P. papatasi, *P. sergenti*, *P. major* transmit *Leishmania tropica* (cutaneous leishmaniasis)

P. argentipes (in India) transmits *L. donovani* causes visceral leishmaniasis

P. chinensis (in China) *L. donovani* transmits visceral leishmaniasis

Phlebotomus intermedius transmits *L. braziliensis* transmits muco-cutaneous (Espundia)

- Bartonellosis / Oroya fever / Carrion's disease (Bacterial disease)
- Three day fever virus in man.

Control

- Elimination of breeding grounds, fill cracks and crevices
- Residual application of DDT= 1- 3 g/m²
- Repellents in cloths or ointments (Vaseline)

Family Simuliidae

- Black flies / Buffalo gnats, 2-3mm.
- Thorax is humped over the head
- Proboscis is short and adapted for piercing
- Antennae long, have 11 segments.
- Legs short, stout
- Body is covered with golden or silver hairs
- Wings are broad and not spotted, bristles on thick anterior veins are present.

Eggs:

- laid on stones and plants just below the surface of water in running streams. In groups of 300-500 and attached with gelatinous secretions to stones and plants. The eggs are triangular in shape (First yellow then black and pointed at one end).
- Laid by the help of ovipositor.

Larva: Yellowish green, cylindrical larva emerges from egg.

- It attaches itself by means of post sucker like organ, which is armed with hooks, but they are able to move about.
- Larvae are carnivorous.
- Ventral surface of prothorax bears an arm like appendage called the proleg- with circle of hooks at its free end used for locomotion.
- Larvae moult 6-7 times.

Pupa: Mature larva, with silken threads from its salivary glands spins a triangular cocoon, resembling an open pocket.

- The dark brown obtectate pupa attached within cocoon by two posterior hooklets and entangling silken threads.
- On each side of thorax there is respiratory tubes, the branches of which float out of the cocoon.
- Imago emerges.

Biology: Found near swiftly running woodland streams in hilly region.

- ♀ bites man and other mammals during the day particularly in morning and evening.
- 4 miles / day flight and wandering 45 to 60 miles.
- Found in northern hemisphere from May to August.

Importance:

- Troublesome in warm countries, annoyance, irritation. Petechial hemorrhages on skin, oedema of throat and abdomen.
- Stampede or away from grazing – bites give rise to vesicles, burst or wart like papules (troublesome in teats)
- Poultry – becomes anaemic.
- *S. indicum* (Potu fly) – found in Himalayan mountains

Vector: Transmits viruses of Eastern equine encephalitis and vesicular stomatitis

Transmits *Leucocytozoon anactis* in ducks, *L. smithi* in turkeys, *L. caulleryi* in fowl

Transmits *Haemoproteus anatis* in ducks and geese

Transmit *Onchocerca gutturosa* in cattle and *O. volvulus* in man (Arica)

Lecture-4

Suborder Brachycera

- Predatory on vertebrates

Family – Tabanidae

- Horse / breeze flies, robust flies with powerful wings and large eyes
- Proboscis is soft and hangs down
- Eyes – holoptic in males, dichoptic in females
- Wing venation is characteristics, R₅ cell is open

| <i>Tabanus</i> | <i>Chrysops</i> | <i>Haematopota</i> |
|--|---|---|
| 1. Proboscis is short 2. First 2 segments of antennae are short and 3 rd are large and have a tooth like projection at its base and 4 annulations 3. Have clear wings, hold horizontal when at rest | 1. Longer 2. First 2 segments are long, 3 rd have 4 annulations 3. Wings have dark bands passing from anterior to posterior border 4. Wings are divergent at rest | 1. Short 2. First segment is large, 2 nd narrower & 3 rd have 3 annulations 3. Wings have characteristic mottling |

Life cycle: eggs laid in vicinity of water, usually on leaves of plants

Larva: hatched larvae drop into the water or on mud, into which they disappear

- Larvae are maggot-like have 11 segments, each segment have 8 fleshy tubercles
- Larvae are carnivorous, mouthparts are prehensile and masticatory
- Three jointed antennae. Large lateral tracheae open on penultimate segment which also bears a retractile siphon tube.
- Larvae feed on small crustacean, even on one-another

Pupa: Brown and sub cylindrical

Abdominal segments are movable.

Anterior part appendages of imago can be distinguished (10-14 day)

Adult (4- 5 months in favourable conditions)

Biology: Summer, fond of sunlight

- Most active on hot, sultry days.

- blood suckers, honey, flower juices.
- Feed on underside of abdomen around navel or on the legs, neck and withers.
- Bite number of times, before they replete.
- Wound created by bite – blood continue to escape and sucked up by nonbiting muscidae.
- Feed about every three days – after feeding nest under side

Importance

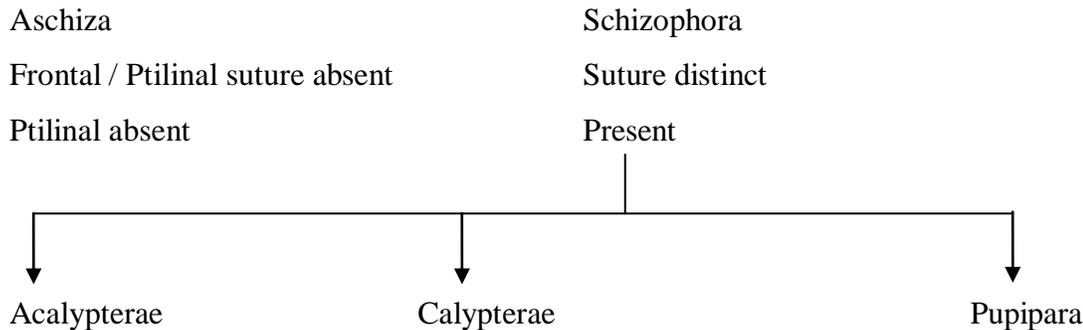
- Painful and irritating
- Give rise to weal's in soft skinned animals.
- Animals are restless, may become unmanageable.
- Mechanical vector of Anthrax, Anaplasmosis, EIA (Equine infectious anaemia), Pasteurellosis.
- *Chrysomya dimidiata* acts as intermediate hosts of *Loa loa* (filarrid nematode)
 - Vectors of *T. evansi* in equines and dogs, *T. equinum* in equines
 - T. simiae* in pigs
 - T. brucei* and *T. vivax* (causes nagana disease in cattle)
 - T. gambiense*, *T. rhodesiense* cause Human African trypanosomiasis
 - T. theileri* – cyclic transmission by *Tabanus* and *Haematopota*

Control: Breeding place is destroyed

- Pour kerosene in water which kills flies when they dip.
- Animals kept away from breeding places during hot part of the days.
- Residual sprays in animal houses.

Lecture-5

Suborder - Cyclorrhapha



| | | |
|--|---------------------------------------|---------------------------------|
| - Squamae small | Squamae well developed | Head closely united with thorax |
| - do not conceal halteres | conceal halteres | Dorso-ventrally flat |
| - Thorax without distinct transvers suture | thorax with distinct transvers suture | integument leathery and horny |

Family - Gasterophilidae

- hairy flies, brown colour, resembling bees
- Reduced mouth parts and functionless
- *Gasterophilus* = equines, *Cobboldia* in elephants
- Larvae of *Gasterophilus* genus are parasite of equines, known as “bots” or “stomach bots”.
- Rarely found in dogs, pigs, birds and man.
- *G. intestinalis* is commonest, 18mm long, dark irregular band runs across either wings.

Biology and life-cycle

- During latter half of the summer and live for few days (3wk).
- The female hovers about the animals with extended ovipositor and repeatedly darts at it to glue an egg to hair.
- Large no. of eggs may be laid in succession.

G. intestinalis - around fetlocks of fore legs, also higher up in legs and scapular region

G. nasalis, *G. pecorum* – hairs of inter-mandibular region.

G. haemorrhoidalis - hairs around the mouth and on cheeks.

Eggs are elongate, pointed at the attached end and operculate at the other end

Eggs hatch in 5-10 days or more

Eggs near to mouth hatch spontaneously

G. intestinalis & *G. pecorum* eggs hatch in response to licking.

Larvae penetrate the mucosa of mouth; gradually wander down in mucosa up to pharynx (in one month).

G. intestinalis Mucosa of tongue

G. haemorrhoidalis Mucosa of tongue

G. pecorum in the mucosa of cheek

G. inermis in the mucosa of cheek

G. haemorrhoidalis - Even pierce the skin of face and wander into mouth, leaving tracks behind them.

G. intestinalis (in tongue 21-28 days) - becomes attached to cardiac portion of stomach
rarely to fundus or pyloric (reddish in colour)

G. nasalis Pale yellow – attach to pylorus and duodenum.

G. pecorum blood red – pharynx and upper part of oesophagus, fundus of stomach

G. haemorrhoidalis red – found in pharynx, latter settle in stomach.

Larvae remain in the host for 10-12 months and reach to the third stage

- measure about 20mm and are brown in colour
- Have dense spines (two rows) on anterior border of the segment
- A pair of distinct mouth hooks on the first segment.

Pass out in faeces (except *G. haemorrhoidalis* larvae of which again attach for few days in rectum)



Pupate in ground (3 to 5 wks)



Fly emerges.

Pathogenesis

- Annoyance
- Stomatitis
- Inflammation which produces ring like thickening around larva in stomach.
- Ulceration of oesophageal region of the stomach.
- Abscess formation, rupture of stomach – peritonitis.
- Stricture of the pylorus – by larvae or tissue reaction

- Larvae at rectum cause irritation and inflammation.

Diagnosis- Eggs, mouth examination, the presence of larvae in faeces

Treatment: Carbon disulphide (by stomach tube), 2-5 ml / kg bwt (18 hour fast prior)

Piperazine + Carbon disulphide (control both bots and ascarids)

Ivermectin - 0.2 mg / kg

Lecture-6

Family: Oestridae

Genus: *Hypoderma* *H. bovis* and *H. lineatum*

- Commonly called Ox warbles or Warbles
- Larval stages of this fly are common parasites of cattle, rarely of man and horses.
- Found only in northern hemisphere.
- Hairy flies, functionless mouthparts.

H. bovis

15 mm long

Hairs on anterior parts of head
and thorax are greenish yellow

Abdomen is covered with light yellow

hairs followed by band of dark hairs ;

Posterior portion bears orange yellow hairs

Northern cattle grub

H. lineatum

13mm long

Yellowish white

---do---

Common cattle grub

Life cycle:

- Occurs in summer
- Active in day when they lay egg
- Eggs 1mm long fixed to hair by means of small terminal clasps especially on legs
- *H. bovis* lay singly *H. lineatum* in row of six or more eggs



Larvae hatch in 4 days, crawl down the hair to skin through which it penetrates



Wander in subcutaneous connective tissue up the leg and then towards diaphragm and gradually increase in size.

L₁ is seen in many different sites of the body including inter-muscular connective tissue, surface of internal organs.

Winter resting sites of L₁ in *H. lineatum* is sub-mucosal connective tissue of oesophageal wall

Winter site of L₁ in *H. bovis* is region of spinal canal and epidural fat.

(They grow in these sites to 12-16mm and reach these sites after months of hatching)

L₂ travel towards the dorsal aspect of body and reach the subcutaneous tissue of the back where they mature to L₃ (spring resting site)

Larva under the skin of back results in swelling (warble) about 3cm in diameter.

Skin over each swelling becomes perforated and larva lies with posterior end against the hole

Stigmal plates directed towards the pore for the purpose of respiration.

This is the warble stage of infection and lasts for 30 days.

Larvae of *H. bovis* are 27-28mm, bear no. of tubercles & small spines on segments, except in last 2 segments

H. lineatum 25mm – bears no. of tubercles and small spines on all segments, except in last one



Mature larvae wriggle out and fall on ground, penetrate it and forms pupa



Fly emerges in 35-36 days by pushing and open the operculum at anterior end

Pathogenesis and economic importance:

- Animals damage themselves on fences and wires or may be killed by gadding (aimless wandering)
- Reduced weight gain and milk yield.
- Reduction in quality of hide.
- Loss in meat production, licked beef (term used for damage caused to meat due to discoloration and gelatinization of meat along the tracks of larvae)
- Aberrant migrations of larvae cause serious results.
- Intracranial migration in equines has been reported.
- Hypersensitivity responses associated with accidental or deliberate rupture of larvae in warbles.

Diagnosis – Swelling of back with larvae in it

- Eggs on hair during summer.
- Immunodiagnostic test.

Treatment

1. Mechanical removal of larvae.
2. Insecticides – Rotenone widely used as a larvicide.

3. Pour on preparations most acceptable (ivermectin, eprinomectin, doramectin, flumethrin). Do not use drugs when larvae are in oesophagus or spinal cord, because death in oesophagus results in oesophagitis with resulting bloat and death of larvae in spinal cord results temporary or permanent paralysis. Dermal application is the best to control this fly.

Family Oestridae

Oestrus ovis

- Adults are hairy flies which have rudimentary mouth parts and do not feed.
- They lay their eggs on animals.
- The larvae are parasitic maggots and consist of 12 segments of which 1st two are fused.
- Oral hooks are present.
- The post stigmata open through semicircular plates, which may be retractile.
- Pupate on ground.
- Feed on body fluids of hosts or on exudates which surrounds them.
- *Oestrus ovis* resembles bee, 1 cm long
- Sheep nasal fly, dark grey colour with small black spots which are prominent on thorax and are covered by light brown hairs.
- Flies hide in warm corners and crevices, early morning sits in sun.
- Fly deposit young larvae around nostril of host.

It crawls upward, sometimes enters cavities which have small openings.

e.g. Turbinate bones or branch of frontal openings.



They are unable to come out due to large size of L₃

↓
Die

L₁ remains in nasal passage (2 wks to 9 months)



L₂ passes into frontal sinuses develops rapidly



Leaves sheep in 25 days



Fully grown larvae crawl out and pupate on ground (3 to six wks or longer)

Young larvae are white or slightly yellow

Mature larvae

- 3 cm long, dark transverse bands on dorsal aspect, grey to brown
- tapering anteriorly, flat posteriorly
- large black oral hooks, connected to internal cephalo-pharyngeal skeleton
- Ventral surface bears rows of small spines.

Pathogenesis

- annoyance
- Animals stops feeding, restless
- Animal shake their head press their nose against ground or b/t other sheep
- Larvae irritate mucosa with hooks spine cause secretion of mucous exudates on which they feed
- Erosion of bones of skull.
- Injury to brains
- High stepping gait and incoordination
Called 'FALSE GID'
- infected sheep has nasal discharge and frequent sneezing
 - Larvae come out with sneezing

Treatment

1. Ivermectin – 0.2 mg/kg bwt.
2. Rafoxanide drench – 7-5 mg/kg bwt.
3. Cruformate Sprayed directly into nostrils
4. Dichorouvos Sprayed directly into nostrils

Control

Difficult

Repellents are short lasting. Feed sheep in narrow trough the edges of which are smeared with tar. Animals smear with tar during feeding, which act as repellent.

Family Muscidae

- Hypopleural bristles are absent
- Median (M) wing vein is more or less parallel to the radial (R_{4+5}) wing vein or curving toward it
- There is no definite elbow bend in the radial vein

Lecture-7

Genus: *Musca* ***M. domestica* (common house fly) & *M. autumnalis* (face fly of cattle)**

- It is synanthrope and occurs associated with man throughout the world, 5-7.5mm in length
- It feeds on everything (milk, sugar, garbage, meat). Females require protein food for maturation of ovaries.
- Generally they are not blood feeders but sometimes they follow other blood feeding flies and feed on decomposing blood and tissue fluid.
- Cell R₅ is nearly closed.
- Arista is bilaterally plumose up to the tip.
- Thorax is yellowish-grey to dark grey and has four longitudinal dark stripes which are equally wide and extend up to the posterior border of the scutum.
- Abdomen has a yellowish ground colour and a median, black, longitudinal stripe which becomes diffuse on 4th segment. In addition to this, the abdomen of female is marked on either side with a diffuse dark band
- Mouthparts adapted for imbibing liquid food.
- Labium is expanded distally into 2 labella which are capable of marked expansion during feeding.
- Median walls of labella are covered by pseudotracheae which bear a system of channels serving to suck up food in liquid form.
- Labella are hollow organs, their cavities are connected with the general body cavity or haemocoel through labium.
- Pressure of haemocoel fluid causes the labella to expand and turn their medial surfaces forwards, so that they can be brought in contact with the food.
- Solid food such as sugar may be made fluid before it is sucked up by ejection on to it of saliva and crop fluid, these drops called vomit-drops.
- Fly regurgitates and defaecates frequently. These habits are important in disease transmission capacity of the fly.

Life cycle: Lay 100-150 eggs at a time, total 1000.

- Fresh horse manure is preferred site for egg laying but the eggs also develop in faeces of other animals and man and in decaying organic materials.
- Eggs 1mm long, creamy white and dorsal surface has 2 curved, rib-like thickenings.
- Eggs hatch in 12-24 hours, grows into maggot (10-12mm) in 3-7 days.
- Body of larva pointed anteriorly and broad posteriorly, which has posterior spiracles.

- Stigmal plates are D-shaped, closed, have a button. The distance between 2 plates is less than the width of a plate. Each plate bearing 3 M-shaped spiracles or winding slits.
- A pair of anterior spiracles is located on 2nd body segment which are fan-shaped, consisting of a stalk and 5-8 papillae each.
- Larva has a pair of oral hooks which connected internally to a chitinous cephalo-pharyngeal skeleton.
- Three moulting occur. Full grown larva leaves the material in which it has developed to pupate in ground.
- Pupa is coarctate, enclosed in puparium.
- Whole cycle takes about 8 days (at 33-35°C).

Importance:

- Transmit virus (poliomyelitis), bacterial infections (typhoid, cholera, anthrax, tuberculosis, leprosy, diarrhoeal and enteric fever), protozoa (*Entamoeba*) and helminths (*Enterobius* and *Ascaris*).
- Act as intermediate hosts of *Coanataenia infundibulum* and *Habronema muscae* and *Draschia megastoma*

Control: control measures should be directed against breeding places of fly such as stables, stockyards, abattoirs, drains, garbage, etc.

- Manure must be frequently and regularly removed from the stables.
- Garbage should be collected in cans with tight fitting lids.
- Use of insecticides (pyrethrin, diazinon, malathion, etc.).

Genus *Stomoxys*

***S. calcitrans* (stable fly)**

- Proboscis is prominent, directed horizontally forwards
- Both male and female are blood sucker on horse, cattle and man. Have small labella.
- M₁₊₂ vein curves gently forward, ending at or behind the apex of the wing. R₅ cell is open.
- Thorax is grey and has four longitudinal dark stripes, of which the lateral pair is narrow and do not reach the end of scutum.
- Abdomen is shorter and broader than that of house fly and has 3 dark spots on each of the 2nd & 3rd segments.

Life cycle: Prefer decaying vegetable matter (straw and hay) for egg laying when these are contaminated with urine, sometimes also lay in horse manure. The material should be moist, otherwise unsuitable.

- Lay 25-50 eggs at a time (total 800). Eggs are dirty-white to yellow, 1mm long and bear a longitudinal groove on one side.
- Larvae fed on vegetable matter. Full grown larva resembles to the larva of *Musca*.
- Stigmal plates are triangular, have 3 S-shaped spiracles on each plate. The distance between 2 plates is more than the width of a plate.
- Pupation takes place in the drier parts of the breeding materials.
- Life cycle completes in about 30 days.
- Adult flies occur in summer and autumn. They prefer a strong light and are not seen in dark stables or houses.
- They are good fliers but do not travel for long distances.
- Flies change its position during feeding or flies to other animals for continue its feed.

Significance: IMH of *Habronema majus*.

- Mechanical transmission of *T. evansi* in equines and dogs, *T. equinum* in equines
T. simiae in pigs
T. brucei and *T. vivax* (causes nagana disease in cattle)
T. gambiense, *T. rhodesiense* cause Human African trypanosomosis
Anthrax

Control: As *Musca*

Lecture-8

Family Hippoboscidae

- Wing venation is reduced and restricted towards anterior border
- Members are larviparous
- Larval stage is very short and turns into pupa immediately

Genus: *Hippobosca* *H. equina* and *H. maculate*

- Commonly called “forest flies” and found on horses and cattle
- Flies are active in summer and attack mostly in sunny weather
- 1cm long, reddish brown colour with pale yellow spots
- Wing veins are crowded together towards the anterior border
- Short, thick palpi ensheath the tip of slender proboscis, the main portion of which is withdrawn into the head during rest.

Life cycle: Larviparous flies, female lays one larva at a time in dry soil or humus of sheltered spots.

- Larva pupate immediately and turn yellow to black
- Larva is subglobular in shape, 5mm in size and has a dark spot at posterior end.
- Length of pupal stage depends on temperature
- Adult flies spend most of their time on the host and not easily disturbed
- They cluster in perineal region and between the hind legs to the pubic region
- Although these flies are good fliers but they do not travel more than a few metres and tend to feed on horse and cattle.

Significance:

- Cause annoyance and irritation
- Transmit non-pathogenic *Trypanosoma theileri* in cattle
- *Haemoproteus* spp. in birds

Control: they can be killed by oil based insecticides containing pyrethrins.

Genus *Melophagus* *M. ovinus* (sheep-ke)

- Also known as “false tick”
- Found on sheep in most parts of the world
- Wingless, hairy, leathery insect, 4-6mm in size
- Head is short, broad and not freely movable

- Thorax is brown, abdomen is broad and greyish-brown
- Legs are strong and armed with stout claws

Life cycle: Keds are permanent ectoparasites

- Larva laid by female attaches to the wool of sheep by a sticky substance.
- Parturition takes few minutes
- Larva is immobile and turns into a chestnut-brown pupa which is ovoid with broad ends.
- Adult female lives for 4-5 months on sheep and produces 10-15 larvae
- Engorged female can live up to 8 days off the host
- Pupae removed from the host can hatch, but emerging adults die soon if they do not find a sheep to feed
- Mainly found in autumn and winter and transmission is by contact
- Sheep with dense, long and clotted fleece spread more infection because keds come to the surface of such fleeces

Significance: Suck blood and heavy infections cause anaemia

- Sheep loose body condition
- Produce severe irritation, causing the sheep to bite, rub and scratch itself, thus damaging the wool
- Faeces of keds produce stains in wool which lowered its quality
- Poorly fed animals, not protected from cold are attacked mostly during winter
- Transmit non-pathogenic *Trypanosoma melophagium*

Control: Numbers are reduced by shearing

- Tip-spraying is effective in short-fleeced sheep while long-fleeced sheep require second treatment

Genus *Pseudolynchia*

P. canariensis

- Dark brown fly, 6mm long and lives on pigeons
- Resembles sheep ked but has a pair of transparent, tapering wings with the venation reduced and concentrated towards anterior border
- Claws are strong and spurred
- Flies move through the feathers, sucking blood and causing painful wounds, especially in young birds
- Copulation takes place on the host and larvae are laid in dark crevices of pigeon houses, in dry dust, in the nests or sometimes on the host

Significance: Transmit *Haemoproteus columbae*- a blood protozoan of pigeons

- Suck blood and cause anaemia

Control: Spraying with carbaryl dust

- Thorough cleaning of pigeon loft and destruction of debris

After hatching, larvae begin to feed, grow fastly & undergone 2 moults in 2-19 days depending on the availability of foods



Mature larvae 10-14mm long, greyish-white to pale yellow in colour & a pair of oral hooks attached to cephalo-pharyngeal skeleton



Larvae are smooth (*Lucilia*, *Calliphora* & *Phormia*) or hairy (*Chrysomyia* spp.). The hairy larvae bear thorn-like, fleshy projections with small spines at their tips on most of the body segments



larvae leave the host & pupate in the ground, some may pupate in the dry parts of carcass or even in the wool of live animals ↓

pupa of hairy larvae retain the projections on their covering

Myiasis: The infestation of living animals with the larvae of dipteran flies. In myiasis only larvae are involved not adults.

Myiasis can be classified as: Cutaneous myiasis caused by blow flies

: Nasal myiasis caused by *Oestrus ovis*

: Visceral myiasis caused by *Hypoderma* and *Gasterophilus* spp.

OR

Obligatory (nasal or visceral myiasis) or facultative (cutaneous myiasis)

Factors affecting prevalence of myiasis: The prevalence of flies is seasonal, because the adults are adapted to definite ranges of temperature and variations of humidity. They are most abundant in late spring and early summer, decreasing in the hottest part of the year and increasing again in autumn. The availability of food for adults & larvae has great importance in their occurrence. Their numbers can be affected by-

- (1) Temperature: High ambient temperature with high humidity, will favour the creation of suitable areas of microclimate in the fleece which attract adult flies.
- (2) Rainfall: Adult flies are not active during rainy season. Persistent rain creates wool rot in fleece which attracts blow flies to lay their eggs immediately after the rain ceases.
- (3) Host susceptibility: is increased where putrefactive odours develop in the fleece. It may be due to soiling of hindquarters with urine or faeces and injuries due to fighting, shearing or barbed wire.

Succession of flies on the host and carcass: the flies can be divided into-

- (1) Primary flies- which are capable to initiate a strike by laying eggs on living animal, e.g. *Lucilia*, *Phormia*, most of species of *Calliphora*.
- (2) Secondary flies- which are not capable to initiate a strike, but lay their eggs on animal already struck. The larvae extending the injury done by the larvae of primary flies, e.g. some *Calliphora* spp., *Chrysomyia* spp., *Sarcophaga* spp. (carrion flies).
- (3) Tertiary flies- which come last of all when the lesion started dry. These larvae do little further damage, e.g. *Musca domestica*, *Fannia* spp.
- (4) The succession of the larvae of primary flies and secondary flies is influenced by competition between them for food and in this battle, the larvae of secondary flies are usually win, particularly that of *Chrysomyia* larvae which are carnivorous in nature. So the larvae of secondary flies once entered into the completion, only few eggs of primary flies give rise to the adult. Hence, secondary flies can be used for the control of primary flies.

Different types of strike:

- (1) Breech or crutch strike: most common form of strike in sheep when the wool in the breech region is soiled & the skin scalded by diarrhoeic faeces & by urine in ewes. The predisposing factors are narrowness of breech and wrinkling of the skin in this area, which favour constant soiling by faeces & urine.
- (2) Tail strike: occurs due to soiling of tail by faeces & urine.
- (3) Pizzle strike: it occurs in rams due to the narrow opening of the penile sheath, which soil the wool of this region with urine.
- (4) Poll strike: rams with deep head folds or with horns lying close to the head develop a “sweaty condition” of the skin of these parts and attract blow flies.
- (5) Body strike: strike caused in the dorsal region of the body due to the prolonged wet weather, when wool becomes soaked with rain & bacterial activity, fleece rot, sets in, predispose to body strike, especially areas over wither is susceptible. Length & fineness of wool are important factors. Sheep with short & coarse wool which dries rapidly, are less susceptible than those with longer & finer wool.

(6) Wound strike: if an undressed wound (due to dog bite, castration, accidents, barbed wire, operations etc.) is present on any part of the body, it may be attacked by blow flies called wound strike. It is most commonly seen on scrotum after castration, on the tail after docking & on the heads of rams after fighting.

Pathogenesis

1. Wool which remained wet for a prolonged period, the yolk, wool scales & skin scales become pasty & form a suitable medium for bacterial growth.
2. An odour produced during bacterial decomposition attracts blow flies to lay their eggs.
3. The larvae of primary flies initiate strike by secreting proteolytic enzymes which digest & liquefy the host tissues.
4. Secondary flies attack and make the wound more extensive. They form tunnels underneath the skin & in the tissues.
5. The central portion of the lesion heals by forming a thick scab and larvae migrate towards periphery extending the lesion.
6. The smell emanating from the lesion further attracts the flies to lay their eggs.
7. The lesion & parasites cause irritation. Animal does not feed properly, and becomes weak & poor.
8. Death may occur due to septicaemia or toxaemia.
9. It causes financial losses due to decreased value of fleece, reduced meat & milk production, and due to the death of animals.

Clinical signs:

1. The affected sheep usually stands with its head down and does not feed.
2. Animal may attempt to bite the affected part.
3. When the lesion situated around the tail or buttocks, the animal will stamp or jerk the hind legs and wag the tail.
4. Wool of the affected part becomes discoloured, greyish-brown and moist with an evil odour.
5. Maggots may be found in the lesion.
6. In advance stage an inflamed ragged wound with a foul-smelling liquid exudate may found.

Treatment:

1. Clipping of wool or hairs around the lesion

2. Use turpentine oil to kill or remove the larvae
3. Dressing of wound with 2% diazinon or use of an antiseptic cream (Lorexane) to prevent further infestation
4. Ivermectin may be used

Control: 1. Selective breeding to reduce narrowness of the breech or folds of skin in this region

2. Surgical removal of the skin folds (Mules operation or mulesing)
3. Docking behind the 4th, instead of 2nd caudal vertebra reduces chances of strike. Short docking tends to produce a stump surrounded by folds- the rose tail which is often struck
4. Clipping of wool from the tail and breech area (crutching)
5. Use of insecticides during fly activity periods
6. Carcass should be burnt or buried properly

Screw-worm myiasis of animals and man

- The name “screw-worm” is given to the larvae of *Callitroga hominivorax* & *C. macellaria* which occur in north and South America, and *Chrysomya bezziana* (Old world screw-worm fly) found in Africa & Asia.
- These flies are closely adapted to parasitic life and they lay eggs only in wounds or sores present on their host body and do not lay eggs in carcasses
- Larvae hatch in 10-12 h and mature in 6-7 days, after which they leave host to pupate in the ground
- The mature larvae are well armed with bands of spines around the segments

Pathogenesis: - cattle, pigs and equines are most frequently affected

- Rainy season predispose the infestation
- Flies deposited eggs on wounds created due to castration, accidents, dehorning, branding, scalding by dips, tick bites
- Flies are attracted on vulva of cow when there is a bloody discharge or on the navels of young calves.
- Penetration & creation of lesion by the larvae are similar to blow fly strike

Treatment and control: - similar to blow fly strike

- **Sterile male technique-** This technique used to eradicate *Callitroga hominivorax* in USA by the release of male flies sterilized by irradiation. This is based on the fact that this fly mates only once in a year, so that mating with sterilized males prevents breeding. For the purpose 50 million irradiated flies were required per week and 36,000 kg of meat to feed their larvae.

Identification key for mites of different genera

1. Single pair of stigmata, lateral and outside the coxa and body is covered with chitinized brown shield and hypostome is absent
 - Mesostigmata
 - a). Chelicerae is long, whip like, the dorsal shield does not extend to posterior border of body and posterior margin is truncated
 - *Dermanyssus*
 - i) Anus is on posterior half of anal plate
 - *D. gallinae*
 - ii) Anus is on anterior half of anal plate
 - *D. sylviarum*
 - b) Chelicerae is shorter, dorsal shield is wide 2/3rd of its length and then suddenly tapers and constitute a tongue shaped form and extends nearer to posterior border
 - *Ornithonyssus*
 - i) Posterior border of dorsal shield tapers like a tongue and extends nearer to posterior border
 - *O. sylviarum*
 - ii) Dorsal plate gradually tapers to a blunt posterior end like a patel of a lotus (posterior end never truncated like a tongue reaches up to posterior end)
 - *O. bursa*
 - 2. Stigmata on gnathosome at base of chelicerae (but absent in *Demodex*). Tarsi without suckers, claws bears bristle. Palps are well developed
 - Prostigmata (Trombidiformis)
 - a) No stigmata, vermiform stumpy leg, penis produdes on dorsal side of male, vulva on ventral side of female
 - *Demodex* spp
 - b) Body is covered with dense hairs and gives a velvety appearance. The last segment of large pedipals apposes a claw on last segment, legs have 7 segment. Scutum bears 5 setae and a pair of sensillae on scutum
 - *Trombicula delhiensis*
 - 3. No dorsal shield, coxa sunk into the body and may bears chitinous extension (epimeres). No stigmata, suckers or caruncle present, palps simple, setae short, globose. Caruncles get attached with pedicles which are unsegmented (Sarcoptidae)
 - Sarcoptiformis

or segmented (Psoroptidae)

a) Globular, cuticle is finely striated and may be interrupted by scaly and spine areas - Sarcoptidae

i) Globose, Dorsum finely striated, triangular scale and spines on dorsum. In female both side of midline of dorsum, 3 short spines anteriorly and 6 longer spine posteriorly. No legs project beyond margin. Epimeres of 3rd and 4th fused to form later bar. Epimeres of 1st pair of legs fused together to a single rod. Anus terminal. Caranle on legs - Male: 1, 2, 4; Female: 1 & 2 - *Sarcoptes scabiei*

ii) Same as *S. scabiei*. But no projecting scale on dorsum, Dorsal striations are broken into a small scaly area resembling 'thumb print' impression. Anus is more dorsal than terminal. Caranle on legs- Male: 1, 2, 4; Female: 1 & 2 - *Notoedres cati*

iii) Same as *S. scabiei*, but dorsum bear thumb print impression. No spine on dorsum. Two longitudinal chitinized bars run from the base of pedipalps to the level of leg and forms a transverse bar. Caranle on leg- Male: 1, 2, 3, 4; Female: no caranle - *Cnemidocoptes* spp.

b). Oval, epimeres are not marked, No anterior vertical setae. Anterior legs do not extend beyond the margin but posterior pars of legs extend beyond the margin of body. Pedicles are 3 segmented (Psoroptes) or unsegmented (*Otodectes* and *Chorioptes*). Male has adanal copulatory suckers on ventral side which engage with copulatory tubercle of female. Posterior end of male has 2 posterior lobes (very prominent in *Psoroptes* and *Chorioptes* but - Psoroptidae

not in *Otodectes*). Ventrally female bears 'U' shaped ovipores just behind the second pair of legs.

- i) Posterior lobes of male bears 2 long and 3 short setae each. Leg 3 is longest and leg 4 is shortest. Caranicle on legs- Male: 1, 2, 3; Female: 1, 2, 4. - *Psoroptes ovis*

- ii) Same as *Psoroptes* but pedicles are unsegmented, prominent copulatory suckers. Male has 2 long broad tape like setae and 3 normal setae on each posterior lobes. Caranicle on legs- Male: 1, 2, 3, 4; Female: 1, 2, 4. - *Chorioptes bovis*

- iii) Same as *Chorioptes* but smaller in size, pedicles unsegmented. Posterior lobes are weakly developed. Caranicle on legs- Male: 1, 2, 3, 4; Female: 1, 2. - *Otodectes cynotis*

- 1, 2, 3, 4 – denotes pairs of legs which bear caranicles or suckers.

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