

***Hippobosca***  
(insect: dipteran)

**Overview**

Arthropods are coelomate metameric invertebrate animals with a chitinous exoskeleton and jointed limbs. They undergo protostomial embryonic development and grow by cuticular moulting (ecdysis). Three main subphyla are recognized: Chelicerata, Crustacea and Hexapoda. Insects are hexapods with three pairs of uniramous legs, three tagmata (head, thorax, abdomen), ectognathous mouthparts with whole-limb mandibles, and one pair of antennae. Diptera (true flies) have two pairs of wings, but the hindwings are reduced to stabilizing halteres. All species are holometabolans and exhibit complete metamorphosis whereby vermiform larval stages undergo pupation and transform into free-flying adults. Several major parasitic groups are recognized: nematocerans (small slender bodies, long filamentous antennae, narrow wings) and brachycerans (larger bodies, short stout antennae, broad wings); the latter being divided into the Tabanomorpha (larval head capsule sclerotized) and the Muscomorpha (larval head not sclerotized, circular-seamed (cyclorrhaphous) pupae). Muscomorphans include the glossinids (tsetse flies), hippoboscids (louse flies), muscids (house flies), calliphorids (blow flies), sarcophagids (flesh flies) and oestrids (bot flies); all with sponging or biting mouthparts. These flies are either ectoparasitic with adults biting hosts (former three groups) or endoparasitic with vermiform larvae developing in host tissues (latter three groups). Hippoboscids (louse flies) are unusual in being dorsoventrally flattened with a soft leathery abdomen. Both sexes have piercing mouthparts and suck blood from mammals and birds. Most are permanent ectoparasites using strong claws on their feet to cling to hairs or feathers. Females are larviparous and pupiparous, depositing developed larvae on the host to attach and undergo pupation. Infestations by *Melophagus* and *Hippobosca* spp. have been associated with unthriftiness in sheep and other mammals.

**Classification:**

Domain: Eukaryota (membrane-bound nucleus)  
Supergroup: Amorphea (unikonts with single flagellum, or nonflagellated amoebae)  
Kingdom: Metazoa (multicellular eukaryotes, heterotrophs, notably animals)  
Group: Protostomia (triploblastic, spiral cleavage)  
Subgroup: Ecdysozoa (cuticle moulted = ecdysis)  
Phylum: Arthropoda (chitinous exoskeleton, segmented body, jointed limbs, haemocoel)  
Subphylum: Hexapoda (three tagmata, three pairs uniramous legs, whole-limb mandibles, Malpighian tubules)  
Class: Insecta (ectognathous mouthparts (bases lie outside head capsule), single pair antennae, many with wings)  
Superorder: Holometabola (Endopterygota) (young do not resemble adults, pupae, with internally developing wings)  
Order: Diptera (true flies, single pair of forewings, hindwings modified into halteres, vermiform larvae)  
Suborder: Brachycera (tabanid/March flies, short stout antennae often with aristae, telmophagy)  
Infraorder: Muscomorpha (Cyclorrhapha) (flies, cyclorrhaphous (circular-seamed) pupae, larval head not sclerotized)  
Division: Schizophora (head with frontal suture (lunule))  
Section: Calyptratae (calypters cover halteres)  
Superfamily: Hippoboscoidea (pupa-bearers)  
Family: Hippoboscidae (flat/louse flies, leathery abdomen, piercing mouthparts, strong claws on feet)  
Genus: *Hippobosca* (parasitic on skin of mammals)  
Species: various species cause irritation

**Parasite biodiversity and host range:** Most Metazoa are multicellular triploblastic animals with differentiated tissues, many being bilaterally symmetrical with a body cavity. Most invertebrate animals are protostomes as their embryonic development involves spiral determinate cleavage. Those that moult their external cuticles during their life-cycles (process known as ecdysis) are grouped together in the unique clade Ecdysozoa, including the nematodes (roundworms), onychophorans (velvet worms), tardigrades (water bears) and arthropods (myriapods, chelicerates, crustaceans and hexapods). Arthropods have small segmented bodies encased in chitinous exoskeletons with articulated limbs. Most species are free-living in terrestrial and aquatic habitats, although a small range are ectoparasitic on other animals, some feeding on the blood or skin of vertebrates. Five subphyla are recognized: Chelicerata, Crustacea, Hexapoda, Myriapoda and Trilobita. Insects are hexapods with six legs, three distinct body parts, two antennae and mouthparts with whole-limb mandibles. Insects are the most biodiverse group on the planet, with millions of species described in numerous taxa. Notorious ectoparasitic species belong to four orders in two superorders: the Hemipteroidea (Exopterygota) containing the orders Hemiptera (bugs) and Phthiraptera (lice); and the Holometabola (Endopterygota) containing the orders Siphonaptera (fleas) and Diptera ('true' flies). Flies are small winged holometabolans that undergo complete (holometabolous) metamorphosis with vermiform larvae undergoing pupation in silk cocoons. Thousands of dipteran species have been described throughout the world, most being free-living saprophages (detritivores) but some being parasitic either as adults biting and feeding on hosts (often haematophagous) or producing larvae that invade host tissues (condition known as myiasis). Two major suborders are recognized: the Nematocera (with small bodies, long filamentous antennae, narrow wings and aquatic larvae and pupae); and the Brachycera (with large bodies, short stout antennae often with aristae and broad wings).

Major parasitic dipteran families	Biodiversity	Parasitic stages	Status	Pathogenesis*	Disease transmission
Suborder: Nematocera (small midges/mosquitoes, thread-horned with long filamentous segmented antennae (= nemato-cera), aquatic life-cycles (larval/pupal stages associated with water), female adults require blood meal before they can lay eggs) (34 families)					
Culicidae (mosquitoes)	3 subfamilies, 70 genera, 3,500 species	adult ♀	obligate	blood-sucking	viral, protozoal, helminth
Psychodidae (moth flies, sand flies)	5 subfamilies, 150 genera, 3,000 species	adult ♀	obligate	blood-feeding	viral, bacterial, protozoal
Simuliidae (black flies)	3 subfamilies, 30 genera, 2,000 species	adult ♀	obligate	blood-feeding	protozoal, helminth
Ceratopogonidae (biting midges)	4 subfamilies, 110 genera, 6,000 species	adult ♀	obligate	blood-feeding	viral, protozoal, helminth
Suborder: Brachycera (large tabanid/March flies, with stout and fewer antennal segments (= brachy-cera), antennae often with arista, females with slashing-sponging mouthparts to pierce skin and feed on pool of blood (telmophagy)) (120 families)					
Infraorder: Tabanomorpha (larval head capsule incomplete posteriorly (only anterior parts sclerotized))					
Tabanidae (horse flies, deer flies)	3-5 subfamilies, 133 genera, 4,300 species	adult ♀ [+ larvae]	obligate [accidental]	blood-feeding [GI, UG, TR myiasis]	viral, bacterial, protozoal, helminth
Infraorder: Muscomorpha (Cyclorrhapha) (aristate antennae, setose bodies, cyclorrhaphous pupa)					
Section: Calyptratae (calypters cover halteres)					
Superfamily: Muscoidea (synanthropic flies)					
Muscidae (house flies, stable flies)	9-10 subfamilies, 190 genera, 4,200 species	adult ♀, ♂ [+ larvae]	obligate [accidental]	biting, blood-feeding [CU, GI, TR myiasis]	bacterial, helminth
Superfamily: Oestroidea (cause larval myiasis) (6 families)					
Calliphoridae (blow flies)	11 subfamilies, 75 genera, 1,100 species	larvae	facultative, obligate	CU, GI, NP, AU, UG TR, myiasis	-
Sarcophagidae (flesh flies)	3 subfamilies, 108 genera, 2,500 species	larvae	facultative, obligate	TR, GI, CU myiasis	-
Oestridae (bot flies, warble flies)	5 subfamilies, 25 genera, 150 species	larvae	obligate	CU, GI, NP, OC myiasis	-
Superfamily: Hippoboscoidea (pupa-bearers)					
Glossinidae (tsetse flies)	1 genus, 3 species-groups, 25 species	adult ♀, ♂	obligate	blood	protozoal
Hippoboscidae (louse flies, keds)	1-3 subfamilies, 21 genera, 212 species	adult ♀, ♂	obligate	blood	viral, protozoal, helminth

\*type of myiasis: AU = auricular; CU = cutaneous; GI = gastro-intestinal; NP = naso-pharyngeal; OC = ocular; TR = traumatic; UG = uro-genital.

The suborder Brachycera contains 6 infraorders: Asilomorpha (bee flies, robber flies, spider flies), Muscomorpha (previously suborder Cyclorrhapha) (house flies, blow flies, fruit flies), Stratiomyomorpha (soldier flies), Tabanomorpha (horse, deer and snipe flies), Vermileonomorpha (wormlions) and Xylophagomorpha (awl flies); all of which vary considerably in their morphological and biological characteristics. Members of the infraorder Muscomorpha differ from the others in that they form cyclorrhaphous (circular-seamed) pupae (adults eclose through a circular cap rather than a longitudinal slit), larvae without sclerotized heads, and adults with short pendulous 3-segmented antennae (the third segment often bearing feather-like arista), palps with a single segment, and feet with 2 pads. Collectively, 15 superfamilies have been classified into 2 Divisions: the Schizophora (containing flies whose heads bear a frontal ptilinal suture and sclerotized lunule); and the Aschiza (hover flies lacking a frontal suture and lunule). Within the Schizophora, 2 sections are recognized: the Calyptratae (comprising flies with calypters covering the halteres, large squamae, a strong thoracic suture and well-defined grooves on the antennal pedicels); and the Acalyptratae (without covering calypters, small squamae, a weak thoracic suture and no pedicel grooves). Calyptratae flies are divided into 3 superfamilies: Muscoidea (synanthropic flies with well-developed sponging mouthparts for feeding on decaying organic material or

biting mouthparts for blood-feeding, most females being oviparous (egg-layers)); Hippoboscoidea (louse flies and tsetse flies with elongate biting mouthparts for blood-feeding, female flies formerly regarded as pupa-bearers and placed in group Pupipara (now defunct) as they have since been shown to birth mature larvae (considered to be prepupae)); and Oestroidea (blow flies, bot flies and flesh flies whose larvae are endoparasitic and cause myiasis).

The superfamily Hippoboscoidea contains 4 families: Glossinidae (tsetse flies); Hippoboscidae (louse flies, some called forest flies, keds or iron flies); Nycteribiidae (bat flies); and Streblidae (bat flies). The family Hippoboscidae contains dorsoventrally flattened flies with piercing mouthparts, leathery abdomens and strong claws on their feet. These ‘flat’ or ‘louse’ flies may be wingless or have wings with veins crowded into the leading half of wing. Members are often found as ectoparasites on many species on wild birds, although some infest ungulates, including domestic livestock. Over 200 species have been described in over 20 genera classified into 1-3 subfamilies. Usually, one subfamily is recognized (Hippoboscinae) albeit with 4 tribes: Hippoboscini with 2 genera (including *Hippobosca*), Lipoptenini with 2 genera (including *Melophagus*), Olfersiini with 3 genera, and Ornithomyini with 6 genera), with another 10 unplaced genera. Alternatively, some authorities have placed parasites of birds into the separate subfamily Ornithomyinae, and melophagine parasites of artiodactyls into the subfamily Melophaginae (or Lipopteninae).

Tribe	Genera	Hosts	Site	Transmission
Hippoboscini	<i>Hippobosca</i>	equids, bovids	skin	direct
Lipoptenini	<i>Melophagus</i>	bovids, cervids	skin	direct

The genus *Hippobosca* (syn. *Hippoboscus*, *Hyppobosca*) contains 7 species of louse flies which are blood feeders commonly infesting cattle and horses around the world. Early workers recognized 3-4 ‘species groups’ on the basis of various differences in adult body morphology, principally involving wings, genitals, abdominal plates and setation. Even though all members of this genus retain their wings, adult flies live almost permanently on their hosts, often in clusters on body parts with little to no hair (e.g. perineum, udders, ventrum). If disturbed, they may fly away but will return very quickly to the same or adjacent hosts. Infestations are a common cause of fly worry which may interfere with livestock production.

<i>Hippobosca</i> species	Hosts	Clinical signs	Distribution
Species group ‘a’			
<i>H. equina</i> (syn. <i>H. taurina</i> ) (horse louse fly, forest fly)	Perissodactyla: equid (horse, donkey, mule); Artiodactyla: bovid (cattle, buffalo, sheep, goat), camelid (camel), cervid (red deer); Lagomorpha: leporid (rabbit); Carnivora: canid (dog); Rodentia: caviid (guinea pig); Primates: hominid (human); Accipitriformes: accipitrid (northern goshawk); Columbiformes: columbid (pigeon); Pelecaniformes: ardeid (grey heron)	irritation (vector for equine piroplasmiasis, bovine trypanosomiasis, Q fever, rickettsioses, avian haemoproteids)	worldwide (esp. Eurasia, Africa)
<i>H. fulva</i> (syn. <i>H. martinaglia</i> )	Artiodactyla: bovid (Kirk’s dik-dik, steenbok, Cape grysbok, duiker, impala, Grant’s gazelle, Lichtenstein’s hartebeest, harnessed bushbuck)	irritation	Africa
<i>H. longipennis</i> (syn. <i>H. canina</i> , <i>capensis</i> , <i>cunicosa</i> , <i>fossulata</i> , <i>francilloni</i> , <i>orientalis</i> ) (dog fly, dog louse fly)	Carnivora: canid (dog, pariah dog, dhole, African wild dog, jackal, red fox, bat-eared fox), felid (cat, African wildcat, cheetah, serval, lion, leopard, lynx), herpestid (mongoose), hyaenid (spotted hyena, striped hyena), mustelid (badger), viverrid (African civet, mongoose); Artiodactyla: bovid (cattle, antelope, duiker, Kirk’s dik-dik), cervid (roe deer); Perissodactyla: equid (mule); Primates: hominid (human); Aves (unspecified birds)	irritation	Africa, Eurasia
Species group ‘b’			
<i>H. camelina</i> (syn. <i>H. bactriana</i> , <i>dromedarina</i> ) (camel fly)	Artiodactyla: camelid (camel, dromedary); Perissodactyla: equid (horse); Primates: hominid (human)	irritation	Africa, Middle-East
Species group ‘c’			
<i>H. hirsuta</i>	Artiodactyla: bovid (waterbuck, puku)	irritation	Africa
<i>H. rufipes</i> (syn. <i>H. albomuculata</i> , <i>albonotata</i> , <i>camelopardalis</i> ) (cattle louse fly)	Artiodactyla: bovid (cattle, hartebeest, black wildebeest, blue wildebeest, springbok, steenbok, korrigum, gemsbok, eland), giraffid (giraffe); Perissodactyla: equid (horse, donkey, Burchell’s zebra); Carnivora: canid (dog); Primates: hominid (human)	irritation	Africa

<i>H. variegata</i> (syn. <i>H. aegyptiaca</i> , <i>bipartita</i> , <i>calopsis</i> , <i>maculata</i> , <i>sudanica</i> ) (horse louse fly)	Perissodactyla: equid (horse, donkey, mule); Artiodactyla: bovid (cattle, water buffalo), camelid (camel, dromedary); Carnivora: canid (dog); Aves (unspecified birds)	irritation	Africa, Asia
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\*The species *H. struthionis* described from ostriches has been transferred to the genus *Struthiobosca*, and the species *H. vespertilionis* described from bats has been synonymized with *Strebla wiedemanni*.

**Parasite morphology:** *Hippobosca* spp. form 4 different types of developmental stages (eggs, larvae, pupae and adults), but they are unusual flies in that the eggs and larvae develop *in utero* within female flies. Eggs develop one at a time in the uterus and appear as translucent creamy ovoid stages around 1mm long. The emergent larvae are retained in the uterus and grow through 3 instars (L1-3) while being nourished on secretions from maternal accessory (milk) glands. The larvae grow up to 4-5 mm long and appear as creamy white-yellow ellipsoidal stages with a dark spot on the body. When L3 cease feeding, they are known as prepupae and are deposited (larviposited) by the female into the external environment. They form a puparium and rapidly darken to black as the encased stage forms a pupa and undergoes metamorphosis to an adult fly. Early studies recognized 3 *Hippobosca* species groups primarily on the basis of morphological differences in adult terminalia, setation, sclerotization and wing venation (with complexity generally increasing through groups 'a', 'b' and 'c'), but it is not yet known whether these groups are supported by molecular characterization studies. Adults are robust shiny brown-black flies, often with yellowish spots marking their dorsoventrally flattened bodies. They range in length from 2-12 mm depending on species, and are sparsely haired and have 2 well-developed forewings. The body has 3 conspicuous tagma: a rounded head; a stout globular thorax; and an expandable ovoid abdomen. The head is not broader than long, and is highly movable, being held clear of the thorax by a short neck. The head bears 2 large brown eyes located laterally and widely separated by the interantennal frons without ocelli. There are 2 small and immovable antennae located in deep rimmed pits, and a pair of stout palps extend forwards and downwards usually forming a sheath around the proboscis. The strongly sclerotized proboscis has piercing-sucking mouthparts for cutting skin and feeding from blood vessels (solenophagy). An elongate labium is the principal piercing structure and has terminal labella armed with teeth. Two long stylets (labrum and hypopharynx) come together when feeding to form a food channel, the latter also having a gutter for the flow of saliva. Blood sucked up by the muscular pharynx is delivered to a tubular oesophagus leading to a globular proventriculus (with saccular crop) before opening into the digestive midgut (without peritrophic matrix), hindgut (with excretory Malpighian tubules), rectum and anus. The midgut contains endosymbiotic bacteria (*Arsenophonus*) within bacteriocytes that may be essential for fly nutrition and survival (while other bacteria, such as *Wolbachia*, detected in other tissues are apparently facultative). The broad thorax is not markedly flattened and is covered by a dorsal scutum with rounded or square shoulders and a posterior lobe-like scutellum. The prothoracic respiratory spiracles open dorsolaterally, and anterior to the points of attachment of the 2 long broad wings, which overlap to cover the abdomen when at rest. Members of the genus *Hippobosca* are permanently winged, unlike some other hippoboscids which shed their wings on finding a host (especially species on birds) or completely lack wings (like *Melophagus*). The wing membranes are supported by 6 primary wing veins [costa (C), subcosta (Sc), radius (R), media (M), cubitus (Cu), and anal (A)] crowded anteriorly (including 2 cross-veins) but trailing posteriorly (without a closed anal cell). The wings appear tinted grey-red and are distinctly crenulated with posterior lobes including a broad alula and distinct calypters covering the stumpy halteres (highly reduced hindwings). The ventral thorax bears 3 pairs of stout hairy legs, each composed of 5 segments (small coxa and trochanter, enlarged femur, flattened tibia, and terminal tarsus), with the latter bearing a pair of large simple claws and pad-like pulvilli. The ovoid-ellipsoid abdomen lacks conspicuous segments and many species also lack dorsal sclerites [species group 'a' with 3 median tergal plates; species group 'b' with 1 plate in males, none in females; species group 'c' lacking plates]. The abdomen is covered by a soft flexible integument allowing for gross distention during feeding and larval development. Adult reproductive organs are located in posterior abdomen with genital ducts opening terminally. Males have 2 testes connected by vas deferens to a seminal vesicle leading to a tubular ejaculatory duct and terminal copulatory apparatus (with retractable phallosome and claspers) [species groups 'a' and 'c' with slender rod-like claspers, species group 'b' with thicker curved claspers]. Females have 2 ovaries (with few ovarioles) connected to a common oviduct expanding posteriorly to form a uterus that accommodates one embryo at a time. The uterus, with associated spermatheca (for sperm storage) and branched accessory (milk) glands, leads to the vulva in the terminal genital plate.

**Site of infection:** *Hippobosca* spp. occur predominantly on mammals (ungulates and carnivores) with some species occasionally biting humans, and a few species rarely infesting birds (raptors, pigeons, heron) (cf. many other hippoboscids occur predominantly on birds). They are obligate ectoparasites and must feed on vertebrate blood in order to survive and reproduce. Adult flies stay in close contact with their hosts and rapidly return or seek nearby hosts if disturbed. Many species are stenoxenous (infest closely-related hosts), but most have strong host preferences either for horses, cattle or carnivores (canids and felids). They feed and rest mostly under the tail around the perineum, between the hindlegs on the inner thigh, around the pubis and genitalia, around the udders in cattle, and sometimes around the head, often places where they are least disturbed by host grooming.

**Pathogenesis:** Louse flies are haematophagous and both sexes feed on vertebrate blood several times a day with bloodmeals lasting up to 15 minutes. If disturbed, flies quickly resume feeding until replete. Their mouthparts are well adapted to blood-feeding and they use their labium with terminal dentate labella to pierce the skin and then the labrum and hypopharynx form a food canal to suck blood as well as inject saliva containing anticoagulant properties. While flies take small volumes of blood, they feed repeatedly and heavy infestations can lead to significant blood loss, sometimes manifest in anaemia. Fly bites are quite painful and

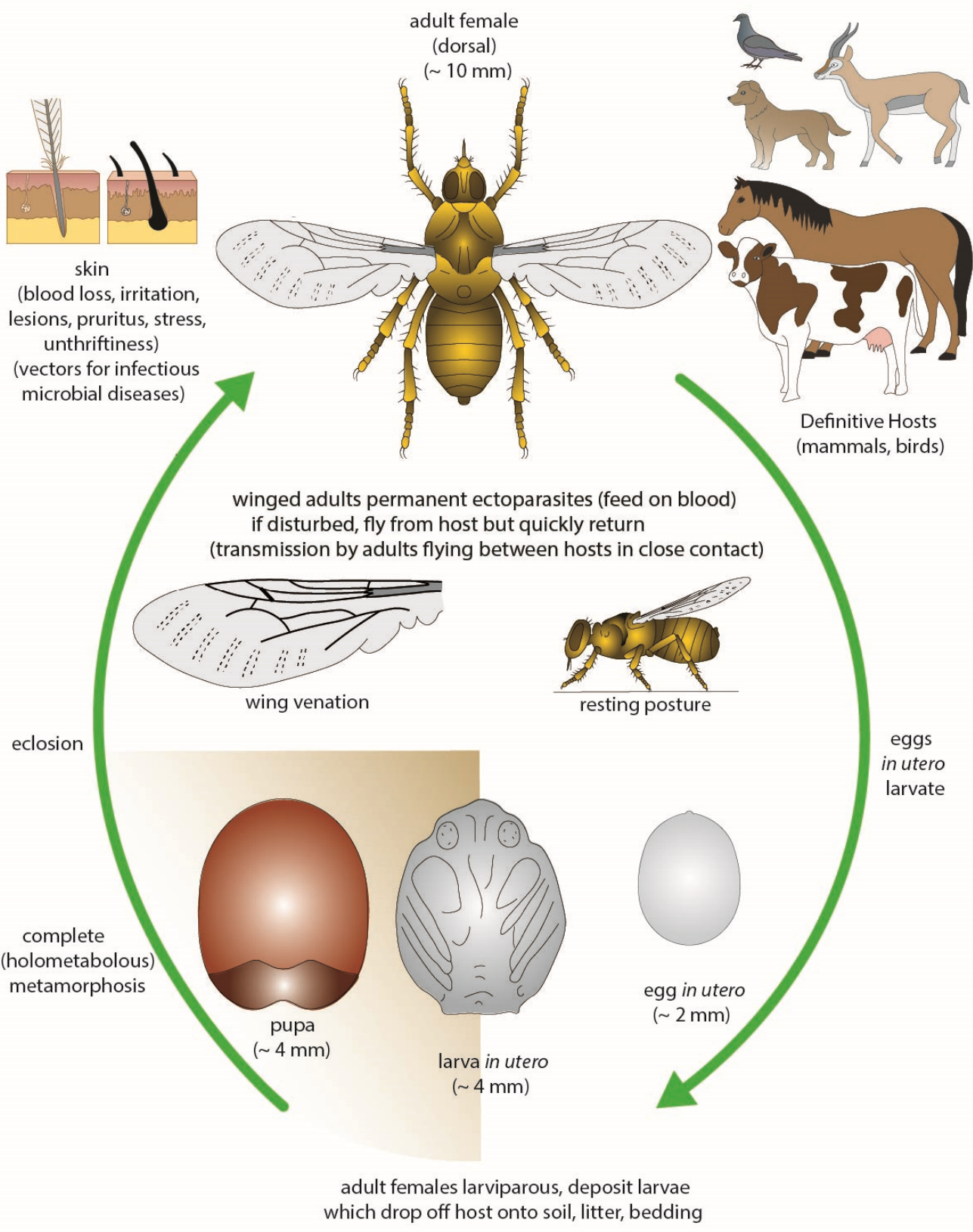
cause traumatic skin lesions, inflammation and pruritus. Hosts exhibit considerable irritation (often called fly worry or biting stress) and resort to behaviours to seek relief from itchy bite sites. They may lick, bite or scratch affected areas, but often rub them against hard objects (walls, trees, fences), sometimes resulting in self-trauma, thus exacerbating wounds and opening them to secondary bacterial or screw-worm infections. Animals may also twitch their tails and limbs nervously, and vigorous stamping by horses has been linked to leg injuries. Animals are distracted from efficient feeding and may exhibit decreased performance, reduced weight gain and even weight loss sometimes leading to emaciation. Individual animals may occasionally develop anaphylactic reactions apparently due to hypersensitivity to fly saliva. Louse flies generally remain in contact with individual hosts and are therefore not renowned for the transmission of infectious diseases. Nevertheless, some louse fly species have been shown to act as vectors for haemoprotozoan parasites (avian haemoproteids (only *Haemoproteus*, as *Parahaemoproteus* are transmitted by ceratopogonid biting midges), nonpathogenic bovine trypanosomes (*Trypanosoma theileri*), bacteria (equine piroplasmiasis, Q fever, rickettsioses and bartonellosis in ruminants) and helminths (filarial nematodes in mammals and birds, incl. *Dipetalonema dracunculoides* in dogs and hyenas).

**Developmental cycle and mode of transmission:** Louse flies live almost permanently on their host, often in clusters on body parts with little to no hair. Transmission between hosts is achieved by adults flying from one host to another, often to those in close proximity, although the adults are good fliers. *Hippobosca* spp. do not shed their wings after finding a host, unlike some other hippoboscids. Like all Diptera, they undergo complete metamorphosis whereby grub-like larvae transform in pupal cases into adult flies. However, unlike most other flies, female louse flies do not lay eggs but retain their eggs one at a time in their reproductive tracts where they release larvae that are nurtured for 3-8 days through 3 instars (L1-3) on secretions from specialized accessory (milk) glands. Female flies only give birth to mature L3 which have ceased feeding (often known as prepupae). This type of reproduction is known as adenotrophic viviparity, and the females are considered to be larviparous (recent texts referring to them as macro-larviparous) as they deposit prepupa which immediately form puparia. Prepupae may be deposited on or off hosts, but they are not glued to hairs (like *Melophagus*) and drop off onto the ground, bedding, nests or roosts. In many species, females fly to adjacent substrates and deposit prepupae in sheltered places in animal holding facilities, in soil cracks and crevices, in humus or debris, and underneath plants near plant roots. The prepupal tegument hardens almost immediately forming a puparium in which pupations occurs over 15-20 days, but up to 142 days for some species in cooler environments. Adult flies emerge and seek hosts on which to feed and mate. Without bloodmeals, flies do not survive off hosts for more than 1-2 weeks. Both sexes may live for up to 4-5 months, but males usually die sooner. Females may produce from 5-15 offspring in their lifetimes. Most species prefer warm sunny weather and are most abundant during summer months.

**Differential diagnosis:** The diagnosis of infestations on clinical grounds is extremely difficult due to the cryptic nature of the flies and the non-specificity of host reactions to fly bites. Diagnosis is generally afforded by close observation of hosts exhibiting fly worry and the direct detection of louse flies biting body parts, mainly under the tail and between the hind legs. Flies may be captured by suction, nets or baits for microscopic examination and identification. Recent molecular biological studies have been used to characterize species and determine phylogenetic relationships following the polymerase chain reaction (PCR) amplification of nuclear (28S ribosomal DNA, caspase-activated Dnase (CAD)) and mitochondrial (16S ribosomal DNA, cytochrome c oxidase subunit I) gene sequences.

**Treatment and control:** Because louse flies stay in close contact with their hosts when resting on the skin in between bloodmeals, infestations on domestic livestock, pets and zoo animals are readily treated with both topical and systemic insecticides. These have included organochlorines (methoxychlor), organophosphates (coumaphos, chlorfenvinphos, malathion, diazinon), synthetic pyrethroids (cypermethrin, deltamethrin, permethrin), carbamates (carbaryl) and arylpyrazoles (fipronil), although macrocyclic lactones appear to be limited in effect at their usual therapeutic doses. The most common and effective treatments currently used for mammals and birds involve monthly spraying with fipronil or deltamethrin, or treatment of animals and their housing with carbaryl-sulphur dust formulations. Some measure of prevention has been achieved by the regular grooming of hosts, probably due to the sustained disturbance of fly populations rather than making feeding and resting sites less hospitable. Because pupation generally occurs in soil and debris in the immediate environment, frequently changing bedding and nesting materials and removing organic wastes will help eliminate deposited pupae and prevent re-infestations.

# Hippobosca





*Hippobosca* adults



*Hippobosca* adult



*Hippobosca* pupa