

Cordylobia
(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). Calliphorids (blow flies) are not parasitic as adults but their larvae help destroy carcasses and may cause traumatic cutaneous myiasis (flystrike, screwworm infestation) in live mammals. Adult flies are large and often metallic in colour. Eggs laid on hosts release larvae which may penetrate the skin to feed on subcutaneous tissues. Most species are facultative invaders, although several are obligate parasites. Larvae of the tumbu fly *Cordylobia* invade the skin of mammals and cause obligate furuncular myiasis.

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 arista, 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)
Family: Calliphoridae (blow flies, often metallic, larvae cause myiasis (flystrike/screwworm infestation))
Genus: *Cordylobia* (tumbu fly) (parasitic on skin/subcutaneous tissues of mammals)
Species: various species cause obligate furuncular myiasis

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 arista 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). Calypterae 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). Several superfamilies contain species whose larvae feed on the flesh of vertebrate hosts, mostly when dead (carrion) but sometimes when still living (causing fly-strike). Oestroid and muscoid larvae are well-adapted for living in moist organic substrates ranging from wet faeces to carrion to living flesh.

The superfamily Oestroidea contains large flies that are not dorsoventrally flattened, their wing veins are not crowded, and the discal medial cell of the wings widens gradually. The superfamily contains 7 families: Calliphoridae (blow flies, written as two words to distinguish them from other fly-like insects with compound names such as dragonflies); Oestridae (bot flies); Polleniidae (cluster flies); Rhinophoridae (woodlouse flies); Sarcophagidae (flesh flies); Tachinidae (parasitic flies); and Ulurumiidae (McAlpine's fly). The family Calliphoridae is characterized by blow flies with metallic iridescent bodies (blue-black, violet-blue, green), strong bristles, well-developed mouthparts and antennae, and weak post-scutellum. The family contains over 1,100 species of blow flies, carrion flies, bluebottles, greenbottles and cluster flies which help destroy carcasses, although many species have been implicated in larval myiasis ('flystrike') in living animals. Most invasions are facultative (opportunistic) causing primary, secondary or tertiary flystrike (categorized according to whether they initiate strike or occur later), although several species (notably screwworms) are obligate parasites whose larvae must develop in flesh. The larvae of most blow fly species are not selective feeders and they exhibit broad host specificity, usually for mammals, occasionally birds and less commonly amphibians and reptiles. Myiasis-causing flies have been found worldwide, particularly in temperate and tropical regions with large domestic livestock populations, but also in cooler regions where wildlife abound. Some 75 genera have been described in 11 subfamilies: Ameniinae, Aphysurinae, Auchmeromyiinae, Calliphorinae, Chrysomyinae, Helicoboscinae, Melanomyiinae, Mesembrinellinae, Phumosiinae, Rhiniinae and Toxotarsinae, with another 14 unplaced genera and several fossil genera. According to various authorities, the subfamily Auchmeromyiinae contains 7-11 genera (including *Cordylobia*). The larvae of most genera appear to be obligate parasites on a range of hosts, some on vertebrates (rodents, ruminants, carnivores and primates) and others on invertebrates (notably ant and termite nests).

Family	Genera	Hosts	Strike	Myiasis*
Calliphoridae	<i>Lucilia</i>	mammals	primary	Facultative (AU, CU, GI, NP, TR, UG)
	<i>Calliphora</i>	mammals	secondary	Facultative (AU, CU, GI, NP, TR, UG)
	<i>Cochliomyia</i>	mammals	primary, secondary	Facultative or obligate (TR)
	<i>Chrysomya</i>	mammals	primary, secondary	Facultative or obligate (TR)
	<i>Cordylobia</i>	mammals	primary	Obligate (CU, TR)

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

The genus *Cordylobia* (syn. *Stasisia*, *Neocordylobia*) contains 3 species whose adults feed on organic matter ranging from rotting fruit and vegetables to animal faeces, while their larvae are endoparasitic in the dermal tissues of mammals where they cause temporary myiasis. Individual larvae cause furuncular (boil-like) lesions superficially in the skin with small opening through which they breathe using their posterior spiracles, each characteristically with 3 curved slits surrounded by a peritreme. Tumbu fly larvae have been found in rodents, carnivores (dogs, cats), wild bovids (esp. antelope) and domestic livestock in tropical areas of sub-Saharan Africa. Humans may be accidentally infected, particularly during the wet season when moist soil (and even clothes) are desirable sites for oviposition, with emergent larvae penetrating any skin in contact.

<i>Cordylobia</i> species*	Hosts	Location	Clinical signs	Distribution
<i>C. anthropophaga</i> (syn. <i>C. grunbergi</i> , <i>murium</i> , <i>Ochromyia</i>) (tumbu fly, mango fly, putzi fly, skin maggot fly, Cayor worm)	Primates: hominid (human); Artiodactyla: bovid (livestock, antelope); Rodentia: caviid (guinea pig); Carnivora: canid (dog); other domestic and wild animals	skin	obligate myiasis (painful swelling, pruritus, serous exudate)	sub-Saharan Africa

<i>C. rodhaini</i> (syn. <i>C. ebadiana</i> , <i>Stasisia</i>) (Lund's fly)	Primates: hominid (human), cercopithecoid (mona monkey); Rodentia: nesomyid (Gambian pouched rat); Artiodactyla: bovid (bay duiker, blue duiker, grey duiker, black-fronted duiker); other wild and domestic animals	skin	obligate myiasis (painful swelling, pruritus, serous exudate)	tropical Africa
<i>C. ruandae</i>	Rodentia: murid (woodland thicket rat); Artiodactyla: bovid (ruminants)	skin	obligate myiasis	Africa

*Various authorities have transferred the nominal species *C. roubaudi* and *C. praegrandis* to the genera *Neocordylobia* and *Pachychoeromyia* respectively.

Parasite Morphology: *Cordylobia* spp. form 4 different types of morphological stages during their developmental cycles: namely, eggs; larvae (3 instars); pupae (inside puparia); and adults (males and females). The eggs are creamy-yellow in colour and ovoid to banana-shaped measuring 0.8-1.0 mm long. Larvae have stout cylindrical white-yellow bodies with a narrow pointed anterior end and a broader truncated posterior end. They develop through 3 instars (L1-3) growing from 1 mm up to 15-33 mm in length depending on species (L3 of *C. anthropophaga* grow up to 11-15 x 5 mm, while those of *C. rodhaini* grow up to 17-33 x 8 mm). Larvae lack sclerotized head capsules but have an internal cephalopharyngeal skeleton with rasping mouthparts (2 hook-shaped labial sclerites). The body has 12 segments without obvious fleshy processes but covered with small sharp cuticular spines (denser on last 5 segments). The spines are usually dark yellow-brown to black, directed backwards, and single toothed. All larvae breathe through 2 pairs of respiratory spiracles: a small anterior pair, each with finger-like processes forming of an irregular clump of openings; and a larger posterior pair located caudal circular plates, each with a weakly sclerotized perimeter (peritreme) framing 3 serpentine slits which are curved in L3 of *C. anthropophaga* and sinuous in *C. rodhaini* (L1 only have 1 slit) [in comparison, oestrid larvae form flat porous spiracular plates]. Mature L3 form barrel-shaped puparia 6-12 mm long, cocoons that contain pupae whose developing appendages are visible externally. Adults eclose through circular caps (like all Cyclorrhapha) and not through longitudinal slits (like Nematocera and Brachycera). Adult tumbu flies have stout compact bodies 7-15 mm long, which are not metallic-coloured (like other blow flies) but are dull yellow-brown or red-brown. The head, thorax and legs are often yellow, and the thorax may also have 2 broad blue-grey dorsal stripes or diffuse patches. Both sexes are similar in appearance (males slightly smaller) and their bodies have many long thick setae in the form of bristles. They have 3 distinct body tagma: a large oval head, thick thorax, and tapering abdomen. The head possesses both a ptilinal suture and facial lunule (like other Oestroidea and Muscoidea, but unlike other calypterate flies), 2 well-developed large dark compound eyes separated by a small frons, and 2 distinctive antennae, each composed of 3 dissimilar segments: a short basal scape; a club-like pedicel with a complete dorsal seam; and an anterior flagellum composed of a single bristle-like arista that is bilaterally plumose (setae on both sides). Fly mouthparts are of the sponging type and do not have piercing elements (adults are not blood-feeders). The mouthparts are contained within a stout downward-directed proboscis flanked by short club-like palps. The proboscis comprises a short rostrum, a longer cylindrical haustellum (with sheath-like labium housing an anterior labrum and a slender hypopharynx) and a flattened terminal sponging labellum. Liquid foods pass through a tubular oesophagus to a globular proventriculus (with saccular diverticulum) then into the digestive midgut, hindgut (with excretory Malpighian tubules), rectum and terminal anus. The thorax is covered by a sclerotized scutum with a posterior lobe-like scutellum. The dorsal surface bears numerous small setae and a small number of larger bristle-like setae, including a vertical row on the meron (lacking on muscoid flies), 3 pairs of dorsocentral bristles, and hypopleural and pteropleural bristles more ventrally located than the presutural bristle. The mesothorax gives rise to 2 narrow clear-brown wings with membranes supported by 6 primary veins [costa (C), subcosta (Sc), radius (R), media (M), cubitus (Cu), and anal (A)]. Tumbu flies have bare stem veins and the lobes along the hind-edge of the wings (calypters or squamae) lack setae. Like all dipterans, the hindwings have been highly reduced to small knob-like halteres used to stabilize flight. Like other calypterate flies, the halteres are covered by the calypters. However, only oestroid and muscoid flies possess bulbous swellings (greater ampulla) below the wing base. Ventrally, the thorax bears 3 pairs of legs, each composed of 5 segments (coxa, trochanter, femur, tibia, and tarsus), all terminating in a pair of claws with pad-like pulvilli surrounding a central bristle (empodium). The segmented abdomen is usually pyriform in shape tapering to a narrow rounded posterior. The visible segments contain lateral spiracles and the posterior segments are usually modified by terminal genital structures (male aedeagus and claspers, female ovipositor). Males have 2 testes connected by vas deferens to a seminal vesicle (with lateral accessory glands) which opens to a tubular ejaculatory duct and retractable copulatory aedeagus. Females with 2 ovaries joined by oviducts to a globular uterus (with associated spermatheca and accessory glands) leading to the vulva and telescoping cylindrical ovipositor.

Site of Infection: Adult flies are free-flying and feed on rotting fruits, vegetables, animal faeces and sometimes carrion. The larvae, however, are obligate parasites that require vertebrate hosts for their development. Larvae infect dogs, cats, rodents and wild bovids (especially antelope) in tropical areas of sub-Saharan Africa, humans sometimes becoming accidentally infected. Larvae penetrate the skin and develop directly under the cuticle, most commonly around the feet, buttocks, lower back, waist and backs of the arms (although they may occur elsewhere). When replete, mature larvae drop from the host to pupate in the soil.

Pathogenesis: Eggs laid on or near host skin release first-stage larvae (L1) which can rapidly penetrate the skin upon contact, often unnoticed by the host. Individual larvae then feed on cutaneous tissues causing furuncular (boil-like) lesions (rather than abraded

expanding lesions like other blow fly larvae, or cavernous lesions like screwworms). The larvae feed, grow and develop through another 2 instars (L2-3) over 1-2 weeks. *C. anthropophaga* larvae develop parallel to the surface of the skin while *C. rodhaini* larvae develop perpendicularly. When replete, mature L3 then exit the host wounds and drop to the ground to pupate. Skin lesions often begin as small sores with erythema surrounding a central puncture site and mild intermittent pruritus developing over 1-2 days. They are often superficial in location and maintain a central opening 2-3 mm in diameter through which the larvae respire using their posterior spiracles. The lesions then develop over several days into painful boil-like furuncles growing up to 15-35 mm in diameter. The 'boils' appear as micro-abscesses becoming surrounded by host inflammatory responses, tissue granulation, and fibrosis. They begin oozing fluids which is a combination of interstitial fluid, serum, blood, immune cells (eosinophils, lymphocytes), tissue debris and larval waste products. Larvae may even be seen protruding from advanced wounds and the sensation of movement within the papules is common. Lesions become red, swollen, pruritic, and tender to touch with pain ranging from periodic stinging to intense throbbing. Systemic effects are usually not noted, although host inflammation to multiple lesions may be accompanied by regional lymphadenopathy and fever. Many patients become distressed and agitated, and some develop malaise and insomnia. In most hosts, larvae do not migrate into deeper tissues, and pain ceases upon exit of the larvae with lesions healing and scarring over weeks but often retaining traces of the central puncture for months. Curiously, secondary bacterial infections of lesions are uncommon, apparently due to the bacteriostatic activity of larval gut secretions. However, there have been reports of bacterial (commonly *Staphylococcus aureus*) and fungal infections exacerbating wounds, sometimes with fever and septicaemia. Hosts may also develop septic or anaphylactic shock if larvae are damaged during inept attempts at removal. Fatalities have been reported in infested dogs, particularly small breeds with thin soft skin that are susceptible to multiple attacks. Larvae may cause significant oedema or may penetrate to deeper tissues. In endemic regions, rats are preferred hosts and may carry larger numbers of larvae than humans and dogs, often with fatal consequences.

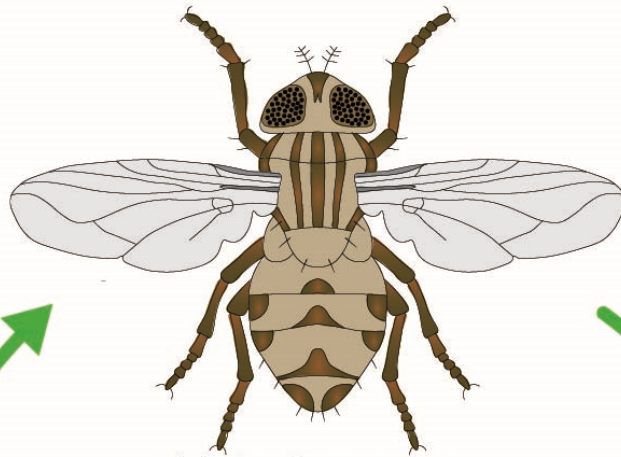
Developmental cycle and mode of transmission: Tumbu flies exhibit holometabolous (complete) metamorphosis in that grub-like larval stages transform in pupae into winged adult insects. Both male and female flies are free-flying and feed on liquids and organic matter from decaying fruits, vegetables, faeces and carrion. Females are oviparous and lay eggs in batches of 100-300 in the morning or evening on dry shaded ground (particularly sandy ground contaminated with urine, faeces or sweat) or on damp or soiled clothing or bed linen. The eggs hatch in 7-20 days releasing first-stage larvae (L1) which adhere to substrates (sand grains or clothing) and remain viable for 2-15 days, depending on conditions (longer in moist conditions). The L1 lie in wait for a host and react rapidly to vibrations and sudden increases in temperature and carbon dioxide. Larvae coming into contact with exposed host skin attach and rapidly penetrate unbroken skin using their oral hooks. Humans often become infected by sleeping on the bare ground, walking over soil with bare feet, or coming into contact with contaminated clothing or bedding (soiled items or those hung out to dry). Once through the skin, larvae do not wander but feed on cutaneous and subcutaneous tissues creating a shallow furuncle (sometimes called a warble). The larvae develop through 3 instars over 7-15 days and they breathe through their caudal spiracles through the central punctum in each wound. When replete, mature L3 cease feeding and leave the host as prepupal stages falling to the ground and burying themselves in surface debris. They form puparia by contraction and hardening of the tegument and the enclosed pupae transform into adults over 10-26 days. Adult flies feed and mate soon after emergence, being most active in the cooler evening or morning but resting in darker places during the day and night (unless attracted to artificial lights). Female flies live for 2-3 weeks and may produce in excess of 500 eggs in their life-times. The whole life-cycle may be completed in 1-2 months, but generally takes longer in cooler regions, flies being most abundant in the wet season.

Differential Diagnosis: Infestations by tumbu fly larvae should be suspected in individuals spending time in endemic areas who have developed non-healing skin lesions that persist for 1-2 weeks and begin discharging exudates from a central punctum. Accompanying signs may include pruritus, tenderness, recurrent pain and sensations of movement within the lesion. Diagnoses are confirmed by the direct observation of larvae within wounds, their removal by forceps or incision, and their identification by examination of their morphological features (particularly spiracles, setae, and mouth hooks). Diagnosis may also be facilitated by rearing larvae in the laboratory on meat or synthetic media until they pupate and release adult flies for examination. Furuncular lesions may also be examined using medical imaging technologies, notably ultrasound and radiography. Modern molecular biological techniques have been used to confirm diagnoses, characterize species and examine phylogenetic relationships by polymerase chain reaction (PCR) amplification of nuclear (ribosomal DNA) and mitochondrial (cytochrome c oxidase) gene sequences.

Treatment and Control: Because mature larvae exit the host wound after 1-2 weeks to pupate in soil, most infestations are considered to be transient and self-limiting. However, the pain and psychological distress associated with furuncular myiasis often predates medical intervention. Larvae can be removed from lesions by careful manipulation with tweezers or probes, but they are sometimes difficult to extract due to their bulbous bodies and tegumental spines. Some clinicians inject boils with lidocaine and epinephrine to help flush out larvae. As last resort, larvae can be removed surgically under local anaesthesia with incision and debridement of the wound, taking care to extract the whole larva as any remaining fragments may cause severe inflammation and granulomas. Treating wounds with insecticides is discouraged as dying or dead larvae can also cause serious inflammatory reactions. Patients are usually given supportive therapies in the form of analgesics, anti-inflammatories, antiseptics, antibiotics and rehydration. Prior to removal, larvae may be smothered by covering the central punctum and spiracles with occlusive dressings of viscous materials (including petroleum jelly, mineral or vegetable oil, liquid paraffin, beeswax, and sometimes butter, nail polish,

adhesive tape and chewing gum). Larvae move closer to the surface and become torpid making them easier to manipulate. Medical imaging technologies can be used to assist precise localization of foreign bodies, notably ultrasonic examination. The prevention of infestations is based around breaking transmission cycles, either by killing adult flies, by limiting the exposure of hosts to infective larvae, and by denying flies access to alternative breeding sites. Residual insecticides and repellents can be used on humans and animals at risk, as well as on potential resting places in the immediate environment. Barriers, screens and nets can be used to provide fly-free housing and sleeping quarters. People should refrain from sleeping on the ground and beds should not be in direct contact with soil. Covered shoes should be worn, even when crossing sandy soils. Improved sanitary and laundry practices should be used to clean and dry clothing (including swimwear) and bedding. Efforts should be made to remove standing faeces, piles of organic debris and any carcasses, as they attract flies for feeding and oviposition. Lastly, attempts should be made to control rodents in communities, as they contribute greatly to sylvatic cycles for tumbu flies.

Cordylobia

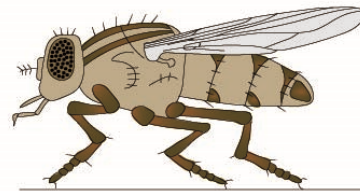


adult female
(dorsal)
(~ 8 mm)

adults free-flying, not parasitic

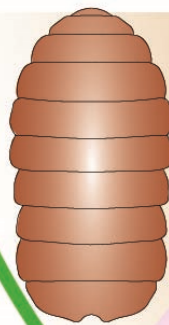


wing venation



resting posture

eclosion



pupa
(~ 10 mm)

complete
(holometabolous)
metamorphosis



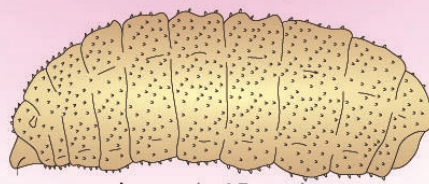
egg
(~ 1 mm)

eggs laid
on ground
or damp
clothing



larval spiracular plates

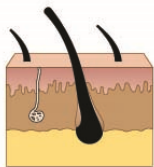
drop from host
to soil



larvae (~ 15 mm)
parasitic (obligate)

hatch

(primary myiasis)
(invade skin and feed
on dermal tissues)



skin
(furuncular lesions,
pain, pruritus,
serous exudates)



Hosts
(mainly mammals)



Cordylobia adult



Cordylobia larva