Phlebotomus, Lutzomyia
(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). Nematocerans include the culicids (mosquitoes), ceratopogonids (midges); simuliids (black flies) and psychodids (sand flies): only the females are parasitic and have piercing-sucking mouthparts. Psychodids include the phlebotomine sand flies, which have characteristically hairy bodies and wings. Adults have cutting mandibles and females feed on plant juices and blood by pool-feeding (telmophagy). They parasitize reptiles, amphibians, birds and mammals, incl. humans. Eggs are laid near decomposing material as the larvae require organic debris on which to feed. Both Old World genera (*Phlebotomus*) and New World/American genera (*Lutzomyia*) are anthropophilic and known to transmit protozoa (leishmaniasis), bacteria (Carrions' disease) and viruses (sand fly fever).

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:	Nematocera (midges/mosquitoes, long filamentous antennae, aquatic larvae/pupae)
Family:	Psychodidae (moth flies/sand flies, incl. phlebotomines, characteristically hairy bodies and wings)
Genus:	*Phlebotomus* (parasitic on skin of mammals/birds)
Genus:	*Lutzomyia* (parasitic on skin of mammals/birds)
Species:	various species cause irritation, pruritus, wheals

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 Hemipterodea (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 aristae, 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 myiases) (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 Nematocera comprises small slender flies that are 'thread-horned' i.e. they possess long filamentous antennae composed of many articulating segments (= nemato-cera). Adults have long narrow wings (with many branching veins) and specialized mouthparts (short or long) with a protective sheath (labium and labellae) protecting feeding stylets (labrum, mandibles, maxillae and hypopharynx) and flanked by 4-5 segmented palps (usually pendulous but slender in mosquitoes). Many species have aquatic life-cycles (larval/pupal stages associated with water) and all undergo complete metamorphosis whereby adults eclose from puparia through longitudinal slits (rather than circular caps like Cyclorrapha). The suborder contains 7 infraorders: Axymyiomorpha (larvae in decomposing wood); Bibionomorpha (gnats, lovebugs); Blephariceromorpha (mountain midges); Culicomorpha (mosquitoes, midges, black flies); Psychodomorpha (moth flies); Ptychopteromorpha (primitive crane flies); and Tipulomorpha (crane flies). Many species are free-living detritivores but some have adapted to bite vertebrate hosts in order to feed on blood. The infraorder Psychodomorpha contains 3 superfamilies: Anisopodoidea (wood gnats), Psychodoidea (moth flies), and Scatopsoidea (dung midges). The superfamily Psychodoidea contains the single family Psychodidae which are collectively and commonly known as moth flies, but includes free-living drain flies, sink flies, filter flies, sewer flies/gnats, as well as haematophagous 'sand flies'.

Psychodid flies have small narrow hairy bodies, large black eyes, long filamentous antennae, long mouthparts with 5-segmented palps, long legs and long narrow pointed and hairy wings with numerous parallel veins running to the wing margins. Over 3,000 psychodid species have been described in over 150 genera in 5 subfamilies: 3 subfamilies containing non-biting flies (namely, Bruchomyiinae with 3 genera; Psychodinae with 104 genera; Trichomyiinae with 1 genus); and 2 subfamilies containing biting flies (Sycoracinae with 2 genera, and Phlebotominae with 27 genera (including *Lutzomyia* and *Phlebotomus*)); with another 12 unplaced genera and 3 fossil genera.

The broad usage of the term 'sand fly' has been a source of some confusion as it has been applied not only to phlebotomines, but sometimes also to quite different flies, notably black flies (family Simuliidae) and biting midges (family Ceratopogonidae). Phlebotomine sand flies have characteristically hairy bodies, well-developed mandibles, long cylindrical antennal segments, and hairy wings (with 2 longitudinal wing veins between radial and medial forks) typically held sloping upwards (trough-like) when at rest. They are found throughout the world, especially in tropical and subtropical regions, with many taxa being confined to either the Old World (Africa, Asia) e.g. *Phlebotomus* and *Sergentomyia,* or the New World (Americas) e.g. *Lutzomyia, Brumptomia,* and *Warileya*. The genus *Phlebotomus* (syn. *Cyniphes, Flebotomus, Haemasson*) contains almost 140 species, most classified in 13 subgenera; while the genus *Lutzomyia* (syn. *Fransaia*, *Lutziola*) contains over 440 species, most classified in 19 subgenera. Adult flies may feed on a wide range of material, including nectar from plants and detritus in moist environments, sewage and decaying organic matter, but the females of most sand fly species are anautogenous and require a bloodmeal from a vertebrate host for their ovaries to complete their development (although some species are autogenous and may complete the first gonotrophic cycle without taking blood). While some species are anthropophilic and will feed on humans, most are zoophilic and feed on an extensive range of animals (domestic and wild mammals, birds, reptiles and amphibians. A growing number of species have gained notoriety as vectors for the transmission of viral, bacterial and protozoal diseases, notably *Leishmania* spp. responsible for cutaneous, mucocutaneous and visceral leishmaniasis in mammals (including humans).

Sand fly species (regional exemplars)	**Host preferences**	**Clinical signs (Vectorial capacity)**	**Distribution**
Phlebotomus aculeatus, alexandri, ansarii, duboscqi, guggisbergi, longipes, papatasi, pedifer, rossi, salehi, sergenti	mammals: primates (incl. humans); rodents (murids, sciurids), carnivores (canids), hyraxes; occasionally birds	irritation, wheals (Old World cutaneous leishmaniasis, sand fly fever virus, Chandipura virus)	Old World (Eurasia, Africa)
P. alexandri, argentipes, ariasi, caucasicus, celiae, chinensis, kandelakii, langeroni, longicuspis, longiductus, martini, neglectus, orientalis, perfiliewi, pernicosus, smirnovi, tobbi, transcaucasicus, vansomerenae	mammals: primates (incl. humans); rodents (murids), carnivores (canids), occasionally bovids	irritation, wheals (Old World visceral leishmaniasis, sand fly fever virus,)	Old World (Eurasia, Africa)
Lutzomyia anduzei, anthophora, ayacuchensis, ayrozai, carrerai, christopheri, diabolica, flaviscutellata, gomezi, hartmanni, intermedia, lichyi, llanosmartini, migonei, nuneztovari, olmeca, ovallesi, panamensis, paraensis, peruensis, pessoai, reducta, spinicrassa, squamiventris, townsendi, shannoni, trapidoi, trinidadensis, ubiquitalis, umbratilis, verrucarum, wellcomei, whitmani, ylephiletor, youngi, yucamensis	mammals: primates (incl. humans), bradypodids (sloths), didelphids (opossums), cingulates (armadillos, anteaters), carnivores (canids, felids, herpestids, procyonids, hystricids), equids, rodents (capromyids, dasyproctids, echimyids, heteromyids, murids, sciurids), occasionally artiodactyls (cattle, sheep, pronghorns, swine), some birds	irritation, wheals (New World cutaneous leishmaniasis, bartonellosis, sandfly fever virus, vesicular stomatitis virus, Changuinola fever virus)	New World (Americas)
L. antunesi, cruzi, evansi, longipalpis	domestic and wild mammals: primates (incl. humans), canids, opossums	irritation, wheals (New World visceral leishmaniasis)	New World (Central and South America)

Full species list (compilation of several on-line data-bases)

***Phlebotomus* species**	**Subgenus**
P. aculeatus	*Larroussius*
P. acuminatus	*Australophlebotomus*
P. alexandri	*Paraphlebotomus*
P. andrejevi	*Paraphlebotomus*
P. angustus	*Adlerius*
P. ansarii	*Synphlebotomus*
P. argentipes	*Euphlebotomus*
P. ariasi	*Larroussius*
P. ashfordi	*Larroussius*
P. asperulus	*Idiophlebotomus*
P. autumnalis	*Euphlebotomus*
P. balcanicus	*Adlerius*
P. barguesae	*Euphlebotomus*
P. berentiensis	*Madaphlebotomus*
P. bergeroti	*Phlebotomus*
P. betisi	*Larroussius*
P. boucheti	*Idiophlebotomus*
P. brevifilis	*Australophlebotomus*
P. brevifiloides	*Australophlebotomus*
P. brevis	*Adlerius*
P. buccinator	*Australophlebotomus*
P. burneyi	*Larroussius*
P. canaaniticus	*Larroussius*
P. caucasicus	*Paraphlebotomus*
P. caudatus	*Euphlebotomus*
P. celiae	*Synphlebotomus*
P. chabaudi	*Paraphlebotomus*
P. chadlii	*Larroussius*
P. chinensis	*Adlerius*
P. chiyankiensis	*Anaphlebotomus*
P. colabaensis	*Anaphlebotomus*
P. comatus	*Adlerius*
P. davidi	*Adlerius*
P. dispar	*Idiophlebotomus*
P. duboscqi	*Phlebotomus*
P. dycei	*Australophlebotomus*
P. economidesi	*Transphlebotomus*
P. eleanorae	*Synphlebotomus*
P. elgonensis	*Larroussius*
P. erebicola	*Idiophlebotomus*
P. fantalensis	*Larroussius*
P. fengi	*Adlerius*
P. fertei	*Madaphlebotomus*
P. fontenillei	*Madaphlebotomus*
P. fortunatarum	*Abonnencius*
P. frondifer	*Idiophlebotomus*
P. galilaeus	*Larroussius*
P. gemetchi	*Paraphlebotomus*
P. gibiensis	*Larroussius*
P. gigas	*Spelaeophlebotomus*
P. gouldi	*Euphlebotomus*
P. grimmi	Unassigned
P. grovei	*Synphlebotomus*
P. guggisbergi	*Larroussius*
P. halepensis	*Adlerius*
P. hoepplii	*Anaphlebotomus*
P. huberti	*Anaphlebotomus*
P. ilami	*Larroussius*
P. jacusieli	*Paraphlebotomus*
P. kabulensis	*Adlerius*
P. kandelakii	*Larroussius*
P. katangensis	*Synphlebotomus*
P. kazeruni	*Paraphlebotomus*
P. keshishiani	*Larroussius*
P. kiangsuensis	*Euphlebotomus*
P. kyreniae	*Adlerius*
P. langeroni	*Larroussius*
P. lengi	*Larroussius*
P. longicuspis	*Larroussius*
P. longiductus	*Adlerius*
P. longipes	*Larroussius*
P. mackerrasi	*Australophlebotomus*
P. maduloae	Unassigned
P. major	*Larroussius*
P. martini	*Synphlebotomus*
P. mascittii	*Larroussius*
P. mascomai	*Euphlebotomus*
P. mesghalii	*Euphlebotomus*
P. minteri	*Spelaeophlebotomus*
P. mireillae	*Paraphlebotomus*
P. mongolensis	*Paraphlebotomus*
P. multihamata	Unassigned
P. nadimi	*Euphlebotomus*
P. naqbenius	*Adlerius*
P. neglectus	*Larroussius*
P. newsteadi	*Synphlebotomus*
P. notteghemae	Unassigned
P. notus	*Larroussius*
P. nuri	*Paraphlebotomus*
P. orientalis	*Larroussius*
P. papatasi	*Phlebotomus*
P. papuensis	*Australophlebotomus*
P. pedifer	*Larroussius*
P. perfiliewi	*Larroussius*
P. perniciosus	*Larroussius*
P. pexopharynx	*Australophlebotomus*
P. philippinensis	*Euphlebotomus*
P. pholetor	*Idiophlebotomus*
P. pungens (fossil)	Unassigned
P. riouxi	*Paraphlebotomus*
P. rodhaini	*Anaphlebotomus*
P. rossi	*Synphlebotomus*
P. rousettus	*Anaphlebotomus*
P. rupester	*Adlerius*
P. saevus	*Paraphlebotomus*
P. salangensis	*Adlerius*
P. salehi	*Phlebotomus*
P. saltiae	*Synphlebotomus*
P. sanctijohani	*Anaphlebotomus*
P. sejunctus	*Idiophlebotomus*
P. sergenti	*Paraphlebotomus*
P. sichuanensis	*Adlerius*
P. sikandraensis	*Synphlebotomus*

P. simici	*Adlerius*
P. sinensis	Unassigned
P. smirnovi	*Larroussius*
P. somaliensis	*Larroussius*
P. stantoni	*Anaphlebotomus*
P. stellae	*Idiophlebotomus*
P. sundarai	Unassigned
P. syriacus	*Larroussius*
P. taylori	*Synphlebotomus*
P. teshi	*Idiophlebotomus*
P. tobbi	*Larroussius*
P. transcaucasicus	*Larroussius*
P. trifilis	*Australophlebotomus*

P. tubifer	*Idiophlebotomus*
P. tumenensis	*Euphlebotomus*
P. turanicus	*Adlerius*
P. vansomerenae	*Synphlebotomus*
P. vaomalalae	*Madaphlebotomus*
P. vaseti	Unassigned
P. vetus (fossil)	Unassigned
P. vincenti	*Madaphlebotomus*
P. wellingsae	*Idiophlebotomus*
P. yunshengensis	*Euphlebotomus*
P. zulrfagarensis	*Adlerius*

***Lutzomyia* species**	**Subgenus**
L. abonnenci	*Psathyromyia*
L. absonodonta	*Micropygomyia*
L. abunaensis	Unassigned
L. acostai	*Trichophoromyia*
L. adamsi	*Helcocyrtomyia*
L. aldafalcaoae	Unassigned
L. alencari	*Lutzomyia*
L. almerioi	*Lutzomyia*
L. alphabetica	Unassigned
L. amarali	*Lutzomyia*
L. amazonensis	*Psychodopygus*
L. amilcari	Unassigned
L. ancashensis	*Lutzomyia*
L. andersoni	Unassigned
L. andina	Unassigned
L. anduzei	*Nyssomyia*
L. antezanai	Unassigned
L. anthophora	*Dampfomyia*
L. antioquiensis	Unassigned
L. antunesi	*Nyssomyia*
L. apache	*Helcocyrtomyia*
L. appendiculata	Unassigned
L. aquilonia	*Coromyia*
L. aragaoi	Unassigned
L. araracuarensis	*Lutzomyia*
L. arevaloi	Unassigned
L. arthuri	*Psychodopygus*
L. atroclavata	*Micropygomyia*
L. atulapai	*Dampfomyia*
L. aulari	Unassigned
L. auraensis	*Trichophoromyia*
L. ayacuchensis	*Helcocyrtomyia*
L. ayrozai	*Psychodopygus*
L. baculus	Unassigned
L. bahiensis	Unassigned
L. baityi	Unassigned
L. barrettoi	Unassigned
L. battistinii	*Lutzomyia*
L. begonae	*Evandromyia*
L. beltrani	*Coromyia*
L. beniensis	*Trichophoromyia*
L. bernalei	*Psychodopygus*
L. bettinii	*Trichophoromyia*
L. bianchigalatiae	*Pintomyia*

L. bibinae	*Nyssomyia*
L. bicolor	*Nyssomyia*
L. bicornuta	*Lutzomyia*
L. bifoliata	*Lutzomyia*
L. bispinosa	*Psychodopygus*
L. blancasi	*Helcocyrtomyia*
L. boliviana	Unassigned
L. borgmeieri	Unassigned
L. botella	*Helcocyrtomyia*
L. bourrouli	*Evandromyia*
L. brachiphallus	*Evandromyia*
L. brachipyga	*Trichophoromyia*
L. brandaoi (fossil)	*Lutzomyia*
L. brasiliensis	Unassigned
L. brazilorum (fossil)	Unassigned
L. breviducta	Unassigned
L. brisolai	Unassigned
L. bursiformis	Unassigned
L. caballeroi	*Helcocyrtomyia*
L. caceresi	Unassigned
L. cajamarcensis	*Pifanomyia*
L. calcarata	*Pressatia*
L. californica	*Micropygomyia*
L. caligata	*Lutzomyia*
L. callipyga	Unassigned
L. caminoi	Unassigned
L. campbelli	*Psathyromyia*
L. campograndensis	Unassigned
L. camposi	*Pressatia*
L. capixaba	Unassigned
L. caprina	*Viannamyia*
L. carmelinoi	Unassigned
L. carpenteri	Unassigned
L. carrerai	*Psychodopygus*
L. carvalhoi	*Lutzomyia*
L. castanea	*Helcocyrtomyia*
L. castanheirai	*Trichophoromyia*
L. castilloi	*Psathyromyia*
L. castroi	*Lutzomyia*
L. cavernicola	*Lutzomyia*
L. cayennensis	*Micropygomyia*
L. ceferinoi	*Helcocyrtomyia*
L. cellulana	*Trichophoromyia*
L. cerqueirai	*Evandromyia*
L. cerradincola	Unassigned

L. chagasi	*Psychodopygus*
L. chassigneti	Unassigned
L. chavinensis	Unassigned
L. chiapanensis	*Micropygomyia*
L. chotensis	Unassigned
L. choti	*Pressatia*
L. christenseni	*Pintomyia*
L. christophei	Unassigned
L. cipoensis	*Lutzomyia*
L. cirrita	*Helcocyrtomyia*
L. claustrei	*Psychodopygus*
L. clitella	*Trichophoromyia*
L. columbiana	Unassigned
L. complexa	*Psychodopygus*
L. conviti	*Trichopygomyia*
L. corossoniensis	*Psychodopygus*
L. correalimai	Unassigned
L. cortelezzii	Unassigned
L. corumbaensis	Unassigned
L. costalimai	Unassigned
L. coutinhoi	Unassigned
L. cratifer	*Psathyromyia*
L. cruciata	*Lutzomyia*
L. cruzi	*Lutzomyia*
L. ctenidophora	*Micropygomyia*
L. cubensis	Unassigned
L. cultellata	*Psathyromyia*
L. damascenoi	*Pintomyia*
L. dasymera	*Psathyromyia*
L. dasypodogeton	*Trichopygomyia*
L. davisi	*Psychodopygus*
L. deleoni	*Coromyia*
L. delpozoi	Unassigned
L. dendrophyla	*Psathyromyia*
L. deorsa	Unassigned
L. depaquiti	*Trichopygomyia*
L. derelicta	Unassigned
L. dereuri	Unassigned
L. diabolica	*Lutzomyia*
L. diazi	Unassigned
L. digitata	*Lutzomyia*
L. disiuncta	Unassigned
L. disneyi	*Coromyia*
L. dispar	*Lutzomyia*
L. dodgei	*Dampfomyia*
L. douradoi	*Psychodopygus*
L. dreisbachi	*Lutzomyia*
L. dubitans	Unassigned
L. duncanae	*Pressatia*
L. dunhami	*Trichophoromyia*
L. duppyorum	*Micropygomyia*
L. durani	*Micropygomyia*
L. dysponeta	*Pressatia*
L. echinatopharynx	*Lutzomyia*
L. edentula	*Nyssomyia*
L. edwardsi	Unassigned
L. elegans	*Trichopygomyia*
L. emberai	Unassigned
L. equatorialis	*Pressatia*
L. erwindonaldoi	*Helcocyrtomyia*
L. eurypyga	*Trichophoromyia*
L. evandroi	Unassigned
L. evangelistai	*Lutzomyia*
L. evansi	Unassigned

L. fairchildi	*Psychodopygus*
L. fairtigi	*Psychodopygus*
L. falcaorum	Unassigned
L. falcata	*Lutzomyia*
L. falquetoi	*Lutzomyia*
L. fariasi	*Viannamyia*
L. farilli	*Micropygomyia*
L. ferreirana	Unassigned
L. ferroae	*Trichopygomyia*
L. firmatoi	Unassigned
L. fischeri	*Pintomyia*
L. flabellata	*Lutzomyia*
L. flaviscutellata	*Nyssomyia*
L. flochi	*Trichophoromyia*
L. fluviatilis	*Sciopemyia*
L. fonsecai	Unassigned
L. forattinii	*Lutzomyia*
L. fraihai	*Nyssomyia*
L. furcata	*Viannamyia*
L. galatiae	*Helcocyrtomyia*
L. gaminarai	*Lutzomyia*
L. gantieri	*Trichopygomyia*
L. gasparviannai	*Lutzomyia*
L. gaucha	*Lutzomyia*
L. geniculata	*Psychodopygus*
L. georgii	*Evandromyia*
L. gibba	*Trichophoromyia*
L. gibsoni	*Pintomyia*
L. goiana	Unassigned
L. gomezi	*Lutzomyia*
L. gonzaloi	*Helcocyrtomyia*
L. gorbitzi	*Migonemyia*
L. grimaldii	*Lutzomyia*
L. gruta	Unassigned
L. guatemalensis	*Psathyromyia*
L. guderiani	*Helcocyrtomyia*
L. guilvardae	*Pifanomyia*
L. guyanensis	*Psychodopygus*
L. hardisoni	*Micropygomyia*
L. hartmanni	*Helcocyrtomyia*
L. hermanlenti	*Lutzomyia*
L. hernandezi	*Nyssomyia*
L. herreri	*Helcocyrtomyia*
L. hirsute	*Psychodopygus*
L. howardi	*Trichophoromyia*
L. huacalquensis	Unassigned
L. ignacioi	Unassigned
L. imperatrix	*Helcocyrtomyia*
L. incasica	*Trichophoromyia*
L. inflata	Unassigned
L. infraspinosa	*Evandromyia*
L. infusca	*Helcocyrtomyia*
L. ininii	*Trichophoromyia*
L. inornata	*Nyssomyia*
L. inpai	*Evandromyia*
L. insolita	*Dampfomyia*
L. intermedia	*Nyssomyia*
L. inusitata	Unassigned
L. ischnacantha	*Lutzomyia*
L. ischyracantha	*Lutzomyia*
L. isopsi	Unassigned
L. isovespertilionis	*Coromyia*
L. killicki	*Psychodopygus*
L. killickorum (fossil)	Unassigned

L. kirigetiensis	*Helcocyrtomyia*
L. kuscheli	*Pintomyia*
L. lainsoni	*Psychodopygus*
L. lanei	*Lutzomyia*
L. larensis	*Helcocyrtomyia*
L. legerae	*Lutzomyia*
L. lenti	*Barrettomyia*
L. leohidalgoi	*Dampfomyia*
L. leonidasdeanei	*Psychodopygus*
L. lerayi	*Psathyromyia*
L. lewisi	*Micropygomyia*
L. lichyi	*Lutzomyia*
L. limafalcaoae	Unassigned
L. llanosmartinsi	*Psychodopygus*
L. lloydi	*Psychodopygus*
L. longiflocosa	Unassigned
L. longipalpis	*Lutzomyia*
L. longipennis	Unassigned
L. longispina	*Trichopygomyia*
L. lopesi	*Trichophoromyia*
L. loretonensis	*Trichophoromyia*
L. luisleoni	*Psychodopygus*
L. lutziana	*Psathyromyia*
L. machupicchu	Unassigned
L. maesi	*Tricholateralis*
L. majuscula	Unassigned
L. mamedei	*Pressatia*
L. manciola	Unassigned
L. mangabeirana	Unassigned
L. maracayensis	Unassigned
L. maranonensis	*Pifanomyia*
L. marinkellei	*Lutzomyia*
L. maripaensis	*Psychodopygus*
L. martinezi	*Trichopygomyia*
L. maruaga	Unassigned
L. matiasi	Unassigned
L. matosi	*Psychodopygus*
L. meirai	*Trichophoromyia*
L. melloi	*Trichophoromyia*
L. microps	*Sciopemyia*
L. micropyga	*Micropygomyia*
L. migonei	*Migonemyia*
L. minasensis	*Micropygomyia*
L. misionensis	Unassigned
L. mollinedoi	Unassigned
L. monstruosa	*Evandromyia*
L. monticolus	Unassigned
L. monzonensis	*Helcocyrtomyia*
L. moralesi	Unassigned
L. moucheti	Unassigned
L. munaypata	Unassigned
L. nadiae	Unassigned
L. naftalekatzi	Unassigned
L. napoensis	*Trichophoromyia*
L. nematoducta	*Sciopemyia*
L. nemorosa	*Trichophoromyia*
L. nevesi	Unassigned
L. nicaraguensis	*Psychodopygus*
L. nociva	*Nyssomyia*
L. nocticola	*Psychodopygus*
L. noguchii	*Helcocyrtomyia*
L. novoae	Unassigned
L. nuneztovari	Unassigned
L. octavioi	*Trichophoromyia*

L. odax	Unassigned
L. oliveirai	*Micropygomyia*
L. olmeca	*Nyssomyia*
L. omagua	*Trichophoromyia*
L. oppidana	*Helcocyrtomyia*
L. oresbia	Unassigned
L. orestes	Unassigned
L. osornoi	*Helcocyrtomyia*
L. oswaldoi	Unassigned
L. ottolinai	Unassigned
L. ovallesi	Unassigned
L. pabloi	*Trichophoromyia*
L. pacae	Unassigned
L. pajoti	*Nyssomyia*
L. paleotownsendi (fossil)	*Lutzomyia*
L. paleotrichia (fossil)	*Lutzomyia*
L. pallidithorax	*Helcocyrtomyia*
L. panamensis	*Psychodopygus*
L. paraensis	*Psychodopygus*
L. parimaensis	*Psychodopygus*
L. pascalei	Unassigned
L. pastazaensis	*Trichophoromyia*
L. paterna (fossil)	Unassigned
L. pelloni	*Lutzomyia*
L. pennyi	*Sciopemyia*
L. perezi	Unassigned
L. permira	*Dampfomyia*
L. peruensis	*Helcocyrtomyia*
L. pescei	*Helcocyrtomyia*
L. pessoai	*Pintomyia*
L. pestanai	*Psathyromyia*
L. petari	*Lutzomyia*
L. petropolitana	Unassigned
L. pia	Unassigned
L. piedraferroi	Unassigned
L. pilosa	Unassigned
L. pinna	*Trichopygomyia*
L. pinottii	*Evandromyia*
L. pisuquia	Unassigned
L. ponsi	Unassigned
L. pradobarrientosi	Unassigned
L. pratti	Unassigned
L. preclara	*Sciopemyia*
L. pseudolongipalpis	Unassigned
L. punctigeniculata	*Psathyromyia*
L. pusilla	Unassigned
L. quadrispinosa	*Micropygomyia*
L. quasitownsendi	Unassigned
L. quechua	Unassigned
L. quillabamba	Unassigned
L. quinquefer	Unassigned
L. rabelloi	Unassigned
L. ramirezi	Unassigned
L. rangeliana	Unassigned
L. ratcliffei	*Trichopygomyia*
L. readyi	*Trichophoromyia*
L. reburra	*Trichophoromyia*
L. reclusa	*Helcocyrtomyia*
L. recurva	*Psychodopygus*
L. reducta	*Nyssomyia*
L. reinerti	*Trichophoromyia*
L. renei	*Lutzomyia*
L. richardwardi	*Nyssomyia*
L. rispaili	*Helcocyrtomyia*

L. robusta	*Pifanomyia*
L. rondoniensis	*Trichopygomyia*
L. rorotaensis	Unassigned
L. rosabali	*Dampfomyia*
L. rostrans	*Trichophoromyia*
L. ruii	*Trichophoromyia*
L. runoides	Unassigned
L. rupicola	Unassigned
L. saccai	Unassigned
L. sallesi	Unassigned
L. saltuosa	*Trichophoromyia*
L. samueli	Unassigned
L. sanguinaria	*Helcocyrtomyia*
L. saulensis	Unassigned
L. sauroida	Unassigned
L. scaffi	*Psathyromyia*
L. schreiberi	*Micropygomyia*
L. scorzai	*Helcocyrtomyia*
L. sericea	Unassigned
L. serrana	Unassigned
L. servulolimai	*Sciopemyia*
L. shannoni	*Psathyromyia*
L. shawi	*Nyssomyia*
L. sherlocki	*Lutzomyia*
L. singularis	Unassigned
L. sinuosa	*Trichophoromyia*
L. sipani	*Evandromyia*
L. soccula	*Psathyromyia*
L. sordellii	*Sciopemyia*
L. souzacastroi	*Psathyromyia*
L. souzalopesi	*Lutzomyia*
L. spathotrichia	*Lutzomyia*
L. spinicrassa	Unassigned
L. squamiventris	*Psychodopygus*
L. steatopyga	*Coromyia*
L. stewarti	*Helcocyrtomyia*
L. strictivilla	*Helcocyrtomyia*
L. suapiensis	Unassigned
L. sylvicolus	*Nyssomyia*
L. tanyopsis	*Psathyromyia*
L. tarapacaensis	*Evandromyia*
L. tejadai	*Helcocyrtomyia*
L. teratodes	*Evandromyia*
L. termitophila	Unassigned
L. texana	*Lutzomyia*
L. thula	*Psychodopygus*
L. tihuiliensis	Unassigned
L. tocaniensis	Unassigned
L. toroensis	Unassigned
L. torrealbai	Unassigned
L. torresi	Unassigned
L. tortura	*Helcocyrtomyia*
L. torvida	Unassigned
L. townsendi	Unassigned
L. trapidoi	*Nyssomyia*
L. triacantha	*Pressatia*
L. trichopyga	*Trichopygomyia*
L. trinidadensis	Unassigned
L. triramula	*Trichopygomyia*
L. trispinosa	*Pressatia*
L. tuberculata	*Viannamyia*
L. turelli	*Trichopygomyia*
L. ubiquitalis	*Trichophoromyia*
L. umbratilis	*Nyssomyia*
L. undulata	*Psathyromyia*
L. valderramai	Unassigned
L. vargasi	*Helcocyrtomyia*
L. vattierae	*Sciopemyia*
L. velascoi	*Trichophoromyia*
L. venezuelensis	*Micropygomyia*
L. verrucarum	Unassigned
L. vesicifera	*Coromyia*
L. vespertilionis	*Coromyia*
L. vexator	*Helcocyrtomyia*
L. viannamartinsi	*Trichophoromyia*
L. vindicator	*Helcocyrtomyia*
L. viriosa	*Coromyia*
L. volcanensis	*Psathyromyia*
L. vonatzingeni	*Lutzomyia*
L. wagleyi	*Trichopygomyia*
L. walkeri	Unassigned
L. waltoni	*Nyssomyia*
L. wattsi	*Helcocyrtomyia*
L. wellcomei	*Psychodopygus*
L. whitmani	*Nyssomyia*
L. wilkersoni	*Trichophoromyia*
L. williamsi	Unassigned
L. wilsoni	Unassigned
L. wirthi	*Micropygomyia*
L. witoto	*Trichopygomyia*
L. xerophila	*Lutzomyia*
L. yasuniensis	*Psychodopygus*
L. yencanensis	*Micropygomyia*
L. ylephiletor	*Nyssomyia*
L. youngi	Unassigned
L. yuilli	*Nyssomyia*
L. zeledoni	*Coromyia*

Parasite morphology: Phlebotomine sand flies form 4 different types of morphological stages during their developmental cycles: eggs; larvae (4 instars); pupae; and adults (males and females). Eggs are elliptical measuring 300-400 x 90-100 µm with rounded ends and one side not as convex as the other. They are pale cream-yellow in colour when laid but darken to amber-brown within 12 hours. The eggs have fine surface markings evident as ellipses, polygons, ridges or pits. Larvae develop through 4 maggot-like stages (L1-4) characterized by the possession of dark or black head capsules, grey-yellow-white segmented bodies (with lateral and dorsal clavate setae) and distinctive elongate caudal setae (1 pair in L1 and 2 pairs in L2-4). Phlebotomine larval segments do not have dorsal sclerites like members of the subfamily Psychodinae. Newly-hatched larvae (L1) measure from 0.5-0.6 mm long and have a protuberance (egg burster) on the dorsal head capsule, while L2-4 have gradually increased in size to 3-5 mm long and do not have egg bursters. The head has short antennae, lateral eyespots, and short chewing mouthparts comprising a labrum, maxillae and dentate mandibles opposing a plate-like serrate mentum. The larvae have prothoracic and caudal spiracles and each abdominal

segment has a short ventral proleg. Just prior to pupation, L4 turn white as they evacuate their gut contents. Pupae are 2-4 mm long and club shaped with the head and thorax curved backwards and the posterior retaining the L4 exuvia which is attached vertically to the substrate. The pupae are obtect, with developing eyes, antennae, legs and wings visible (closely appressed to the body). The prothorax has a pair of short tube-like respiratory organs and the abdomen is highly setate. Pupae are pale creamy-white in colour, but darken to brown-orange prior to eclosion. Adult flies have small narrow grey-brown-yellow bodies measuring 2-5 mm long that characteristically have 'moth-like' hairy features. The head is small and elongate, with 2 large black compound eyes, no ocelli, and a pair of long slender filiform antennae (12-16 segments) covered with short setae (each segment also bearing a whorl of long setae). Phlebotomine flies have a beak-like proboscis with piercing-sucking mouthparts directed downwards and at least as long as the head. The proboscis is flanked by long recurved palps (5 segments) with scattered setae (the longest palpal segment is the third in *Lutzomyia* and the fifth in *Phlebotomus*). In females, the mouthparts consist of lanceolate stylets (labrum, paired dentate mandibles, paired dentate maxillae, and hypopharynx) which are held in a fleshy labium when not in use. In males, the mouthparts are weakly developed, contain few or no teeth, and mandibles are not present. Ingested foods travel through a tubular oesophagus to a globular proventriculus with saccular diverticula and then passed to the tubular gut (midgut for digestion, hindgut with Malpighian excretory tubules, rectum with expandable ampulla, and terminal anus). The thorax possesses a distinctive ventral hump which is densely covered with long thin setae. The dorsal scutum bears 2 large ovate-elliptical wings which are typically held erect over the thorax when at rest. The wings have a thick covering of small hairs and the wing membranes are supported by 6 primary veins [costa (C), subcosta (Sc), radius (R), media (M), cubitus (Cu), and anal (A)] with most running parallel (particularly those between R and M forks) and cross-veins only found in the inner third. Like all dipteran flies, a second pair of wings are found along the posterior thorax but are highly reduced to a pair of knob-like halteres used to stabilize flight. The ventral thorax gives rise to 6 stilt-like legs, each with 5 segments (coxa, trochanter, femur, tibia, and tarsus) terminating in a pair of small claws with a central pad. The elliptical abdomen contains 6-8 segments which are also covered with long thin setae. The abdomen usually has 7 pairs of lateral spiracles, and the terminal segments are modified by external genitalia (genital plates with ducts opening ventrally, females with anal recti and ovipositors, males with caudal claspers). Males have 2 testes connected by vas deferens to a seminal vesicle (with lateral accessory glands) leading to the ejaculatory duct and retractable copulatory aedeagus. Females have 2 ovaries (with polytrophic ovarioles) joined by oviducts to a globular uterus, often with associated spermatheca and accessory glands, leading to the vulva and caudal ovipositor.

Site of infection: Female phlebotomine sand flies are haematophagous and take bloodmeals from vertebrate hosts, including mammals (esp. humans, domestic and companion animals, wild ungulates and rodents), birds (poultry, aviary birds, and ground-dwelling birds), reptiles (snakes and lizards) and some amphibians. Sand flies vary in their host specificities, with some species being euryxenous and feeding opportunistically on available hosts, while others are stenoxenous and feed on several, often closely-related, hosts. A few species feed preferentially (sometimes exclusively) on birds or bats. Many species are anthropophilic and will feed on humans, but they are also zoophilic and feed on animals. Sand flies bite exposed skin, often on limb extremities (hands/feet, ankles/wrists) but also on hairless or sparsely-covered areas (face, nose, lips, eyelids, ears, neck and tail). They are unable to bite through clothing. All pre-adult developmental stages (eggs, larvae and pupae) are free-living in humid terrestrial environments.

Pathogenesis: Adult female flies are annoying biting pests that often probe and bite repeatedly before feeding to repletion. They use their scissor-like mandibles to cut the skin and underlying blood vessels while their toothed maxillae hold onto the sides of the wound to keep the mouthparts in place. Sand flies are telmophagous (pool feeders) and feed on blood haemorrhaging into the wound using a food canal formed between the anterior labrum and posterior hypopharynx, the latter also having a groove for the injection of saliva into the wound. Sand fly saliva has been shown to contain many vaso-active compounds to assist feeding, including spreading agents (hyaluronidase), vasodilators and anticoagulants. While sand flies rarely feed in large numbers, their bites are sharp and painful causing intense irritation to the host for the duration of feeding (up to 3 minutes if not disturbed). Most species are crepuscular and nocturnally active and therefore interfere with sleep by waking hosts or keeping them awake. Bite sites become apparent as red-pink papules (2-3 mm in diameter, 0.5 mm high) which remain prominent for 4-5 days. The inflammation is often accompanied by intense pruritus causing further agitation and frustration, particularly in children. Self-trauma due to scratching may exacerbate wounds, making them susceptible to secondary bacterial infections. Initial bites typically induce sensitization to salivary components, so that subsequent bites result in allergic reactions (immediate and delayed hypersensitivity) with transient erythema, hives, swelling of the eyelids or lips, blistered papules that discharge serum, and occasionally systemic reactions including fever, nausea and debility. Eventually, most hosts experiencing long-term chronic exposure become desensitized and no longer develop hypersensitivity reactions. Many sand fly species have also gained notoriety as very efficient biological vectors for transmission of infectious diseases, particularly those caused by viruses (Pappataci or sand fly fever in rodents and primates, Changuinola fever in sloths, Chandipura in hedgehogs, vesicular stomatitis in ungulates and wildlife), bacteria (bartonellosis or Carrion's disease in humans) and protozoa (notably, *Leishmania* spp. causing disfiguring and deadly cutaneous, mucocutaneous and visceral leishmaniasis in humans and some animals).

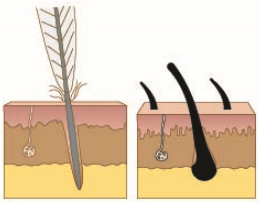
Developmental cycle and mode of transmission: Sand flies undergo complete metamorphosis whereby eggs hatch grub-like larvae which transform in pupae to free-flying adults. Gravid females typically lay eggs in small batches (30-100) in damp and cool terrestrial environments where decaying organic material is present: including crevices in moist soil, rocks and rubble; forest litter, around tree roots, hollows and crotches; manure; animal structures (burrows, dens, nests, even termite mounds) and man-made

structures (houses, sheds, cellars, toilets, barns, stables, and wells). The eggs hatch in 4-20 days and the emergent larvae are free-living scavengers feeding on organic debris, such as decaying plant material, fungi, microorganisms and faeces. Four larval stages occur over 20-60 days, but in cold climates, some species exhibit developmental quiescence (diapause) as eggs or larvae which may last up to a year in unfavourable conditions. The final larval instars form pupae which undergo metamorphosis over 5-10 days, longer in cooler climates. Adult flies emerge and both sexes feed on plant nectar, sap and honeydew. The females of most species, however, are anautogenous and require one or more blood meals to complete each gonotrophic cycle. A few species are autogenous and may complete the first cycle without a bloodmeal, but need one for subsequent cycles. Mating may occur before or after blood-feeding. Females lay eggs approximately 4-10 days after feeding, and they can then return for another bloodmeal to undergo another ovarian cycle within 48-72 hours. Adult flies rest in moist and dark refugia (walls, cracks, tree trunks, caves, burrows) during the day and emerge to feed at night, dawn or dusk. *Phlebotomus* spp. feed mainly on mammals in savannah and desert areas, while *Lutzomyia* spp. feed on mammals and reptiles in damper forested areas. Female flies use a variety of visual, chemical, thermal and tactile sensors to seek hosts, often entering houses apparently attracted by light. Sand flies walk with a distinctive hesitating movement and have limited powers of flight. They fly noiselessly and horizontally to ground in characteristic short hops (several cm) when wind speeds are low (flight impeded when wind speed is >5 kph). Many species only disperse 100-200 m from their breeding sites, rarely ranging up to 2 km even over several days. Adult dispersal is usually not wind-assisted as they remain in their refugia and do not fly in windy conditions. Some neotropical species have been found to move vertically between the forest floor and canopy, with a flight range of 200-500 m. Most adult flies live for several (2-6) weeks, and the entire life-cycle may be completed in as little as 21-60 days depending on species, temperature, humidity, photoperiod, food availability, but can be extended up to a year in species which undergo egg/larval diapause ((many Palaearctic species have 2 generations per year).

Differential diagnosis: Clinical signs exhibited by humans and animals are not specific enough to facilitate diagnosis, as painful bites, rosy papules and pruritus may be caused by a range of ectoparasites. Diagnosis is best afforded by the direct demonstration of sand flies at bite sites, that is, small, hairy, silent, hopping flies with distinctively upwardly-pointed wings (forming a vertical 'V') when at rest. Differential diagnosis is achieved by microscopically examining flies captured by means of suction tubes, adhesive papers, light traps, or baits both from hosts and resting areas (smoke, insect repellants and even feather dusters may be used to flush flies from cryptic resting sites). The identification of phlebotomine species is difficult and clearing adult specimens and examining internal structures (notably mouthparts and genitalia). Phlebotomine species have also been identified from environmental samples (soil and litter) following the extraction of larvae using Berlese funnels, sieving and floatation techniques as well as waiting for adults to emerge from pupae. More recently, molecular biological techniques have been used to characterize phlebotomine species (particularly those involved in the transmission of leishmaniasis) by polymerase chain reaction (PCR) amplification of nuclear (ribosomal DNA) and mitochondrial (cytochrome) gene sequences.

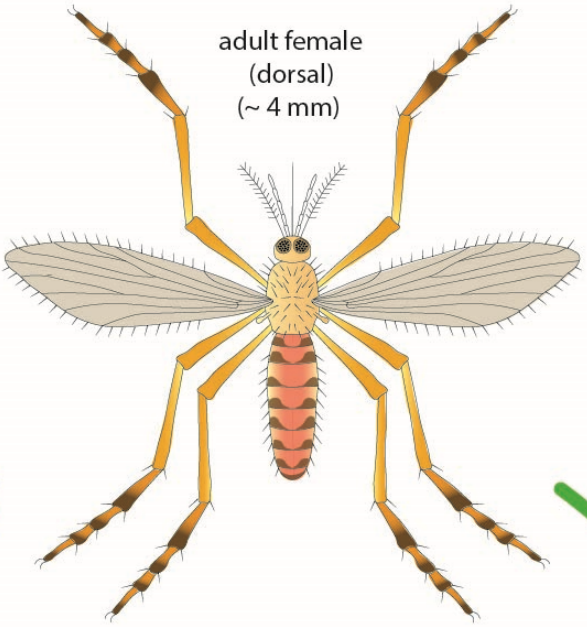
Treatment and control: Sand fly bites in humans can be treated with topical anti-inflammatory, antipruritic and antiseptic formulations to provide symptomatic relief and prevent secondary infections. Systemic glucocorticoids and antihistamines may also be required in individuals experiencing severe allergic and hypersensitivity reactions. A range of insecticides have been administered to animals as sprays, pour-ons or systemic formulations to protect them against sand fly bites, including organochlorines (such as dichlorodiphenyltrichloroethane (DDT)), organophosphates (malathion), carbamates (carbaryl), natural and synthetic pyrethrins (cyhalothrin, permethrin, cypermethrin, cyfluthrin, etofenprox) and chloronicotinyles (imidacloprid). Insecticides with good residual activity have also been used to treat indoor fixtures where sand flies may rest, including walls, ceilings, doors, window frames and screens. Personal protection may be afforded by covering bare skin with clothing, using insect repellents (permethrin, diethymethylbenzamide (DEET), piperidene, neem oil) on skin and/or clothing, and using mosquito coils to generate insecticidal smoke indoors (pyrethroids mixed with slow-burning filler). Attempts to use insecticides to treat potential breeding sites (moist terrestrial habitats) have met with limited success due to their widespread, diverse and often inaccessible locations. In addition, sand fly populations rapidly developed resistance to DDT and it was discontinued in most countries (also due to significant toxicity and environmental concerns). Increasing resistance has been reported against various pyrethroids. Several studies have reported moderate successes using insecticide-treated sugar/fruit baits to attract flies, while a few studies have used male pheromones to attract females to insecticidal baits. Various countries advocate the use of indoor barriers in the form of fine-mesh nets and screens, preferably impregnated with insect repellents or insecticides as sand flies may pass through coarse untreated barriers. Successful control or mitigation programmes also rely on the elimination of potential breeding and resting sites, through building maintenance (repairing cracks in structures, removing rubble heaps and termite mounds, relocating storage piles), improved hygiene (clearing dumps and organic refuse), vegetation control (remove plants used as food sources, sometime regions resorting to local deforestation, introduce plants toxic to sand flies such as *Bougainvillea, Ricinus* and *Solanum* spp.,) and change animal management practices (temporary relocation of livestock, reposition camps to dry ground, favour windy areas, cull reservoir hosts, notably canids and rodents).

Phlebotomus



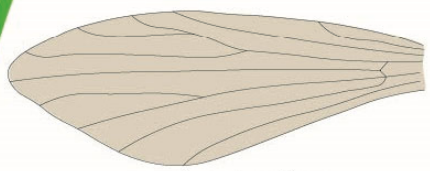
skin
(annoyance, lesions, pruritus, allergy)
(vectors for infectious microbial diseases)

adult female
(dorsal)
(~ 4 mm)

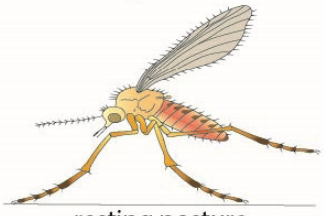


Definitive Hosts
(mammals, birds, reptiles, frogs)

adults free-flying, females of most species are transient ectoparasites (require bloodmeal for reproduction)

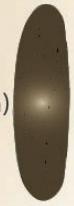


wing venation



resting posture

eggs laid on moist organic substrates



egg
(~ 350 µm)

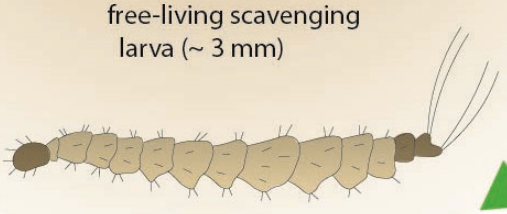
hatch

pupa
(~ 3 mm)

eclosion

complete (holometabolous) metamorphosis

free-living scavenging larva (~ 3 mm)

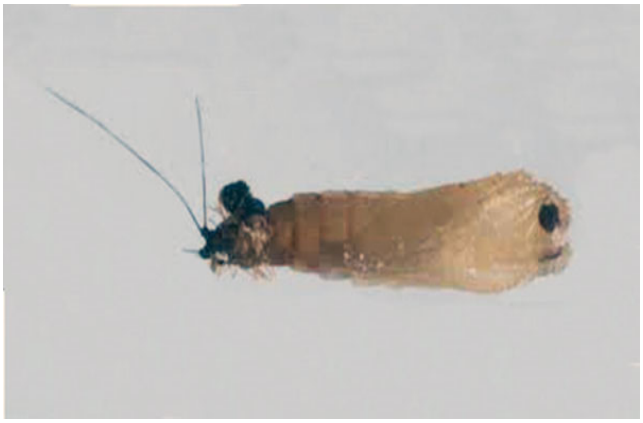


development in humid terrrestrial habitats
(rubble/rocks, soil, litter, manure)

Phlebotomus adult

Phlebotomus eggs

Phlebotomus larva



Phlebotomus pupa