

Trombicula, Eutrombicula, Neotrombicula, Leptotrombicula
(arachnid: mite)

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. Arachnids have chelicerate mouthparts, two tagmata (cephalothorax and abdomen), four pairs of legs and slit sensilla, but no antennae or wings. All species exhibit incomplete metamorphosis whereby eggs hatch larvae which moult to nymphs and then adults. Acarines comprise the ticks and mites which have sac-like bodies with inconspicuous segmentation and their mouthparts are confined to an anterior gnathosoma. Four major groups are recognized primarily on the location of their respiratory stigmata: ixodid ticks (Metastigmata), gamesid mites (Mesostigmata), trombidiform mites (Prostigmata) and sarcoptiform mites (Astigmata). Ectoparasitic mites inhabit the skin of mammals and birds, feeding on fluids and/or tissues. Most spend their entire lives on individual hosts, so horizontal transmission between hosts is primarily by physical contact. Trombidiform mites have stigmata on the gnathosoma and distinct setae on their bodies and legs. Many species are free-living, some have been associated with allergy (including asthma), and several are obligate ectoparasites on mammals or birds. Trombiculid mites are free-living pasture mites whose larval stages are facultative parasites on mammalian and avian hosts. Infestations by a small range of species belonging to different genera may cause dermatitis and allergic hypersensitivity in domestic animals and humans in close contact with pastures.

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: Chelicerata (chelicerate mouthparts, two tagmata, no antennae)
Class: Arachnida (spiders & allies, four pairs of legs, slit sensilla, incomplete metamorphosis)
Subclass: Acari (Acarina) (ticks and mites, segmentation inconspicuous, sac-like body, mouthparts on gnathosoma)
Superorder: Acariformes (diverse group of mites, without posterior stigmata)
Order: Prostigmata [Trombidiformes] (sucking mites, stigmata on gnathosoma)
Suborder: Anystina (legs with thumb-claw process, free-living predatory mites, but some with parasitic larvae)
Superfamily: Trombidioidea (larval stages parasitic, nymphs calyptostatic or free-living, adults free-living predators)
Family: Trombiculidae (hexapod larvae with oval bodies, feathery setae, most legs with claws)
Genus: *Trombicula* (parasitic on skin of mammals/birds)
Genus: *Eutrombicula* (parasitic on skin of mammals/birds)
Genus: *Neotrombicula* (parasitic on skin of mammals/birds)
Genus: *Leptotrombicula* (parasitic on skin of mammals/birds)
Species: various species cause dermatitis in mammals

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. The chelicerates typically have appendages (cheliceræ) in the form of pincers or fangs anterior to the mouthparts, 2 body parts (cephalothorax and abdomen), but no antennae or wings. Three classes are recognized: Arachnida (spiders and allies), Merostomata (horseshoe crabs) and Pycnogonida (sea spiders). Arachnids have 8 legs, slit sensilla and life-cycles involving incomplete metamorphosis whereby larvae and nymphs resemble adults. They are classified in 4 orders: Acari (acarines), Araneae (spiders), Opiliones (harvestmen) and Scorpiones (scorpions). The Acari comprises the ticks and mites which have sac-like bodies and mouthparts confined to an anterior gnathosoma. Four major groups are recognized primarily on the location of their respiratory stigmata (called spiracles in insects): ixodid ticks (posterior Metastigmata), gamesid mites (middle Mesostigmata), trombidiform mites (anterior Prostigmata) and sarcoptiform mites (without stigmata = Astigmata).

Major parasitic families	Biodiversity	Hosts	Parasitic stages	Pathogenesis	Disease transmission
Superorder: Parasitiformes (ticks and some mites, with posterior stigmata)					
Order: Ixodida [Metastigmata] (ticks, macroscopic, stigmata posterior to legs) [3 families]					
Argasidae (soft ticks)	5 genera, 193 species	birds, mammals	larvae, nymphs, adults	blood-sucking	viral, bacterial
Ixodidae (hard ticks)	14 genera, 705 species	birds, mammals	larvae, nymphs, adults	blood-sucking, paralysis	viral, bacterial, protozoal
Order: Mesostigmata [Gamasida] (gamesid mites, stigmata between 2 nd & 4 th legs) [100 families, 662 genera, 5,360 species]					
Macronyssidae (sucking mites)	26 genera, 127 species	birds, reptiles, mammals	nymphs, adults	blood-sucking	bacterial
Dermanyssidae (sucking mites)	5 genera, 37 species	birds, mammals	nymphs, adults	blood-sucking	viral, bacterial
Halarachnidae (lung/ear mites)	7 genera, 10 species	mammals	nymphs, adults	mucosal erosion	-
Raillietiidae (ear mites)	1 genus, 7 species	mammals	nymphs, adults	ear wax	-
Rhinonyssidae (nasal mites)	30 genera, 160 species	birds	nymphs, adults	inflammation	-
Varroidae (bee mites)	1 genus, 5 species	bees	nymphs, adults	haemolymph-feeding	viral
Superorder: Acariformes (diverse group of mites, without posterior stigmata) [351 families, 32,000 species]					
Order: Prostigmata [Trombidiformes, Actinedida] (sucking mites, stigmata on gnathosoma) [121 families, 17,000 species]					
Demodecidae (follicle mites)	7 genera, 65 species	mammals	larvae, nymphs, adults	inflammation	-
Cheyletidae (fur mites)	80 genera, 500 species	mammals (dogs, cats, rabbits), birds	larvae, nymphs, adults	pruritus	-
Myobiidae (fur mites)	46 genera, 185 species	mammals (rodents, bats, marsupials)	larvae, nymphs, adults	mange	-
Psorergatidae (itch mites)	3 genera, 77 species	mammals (rodents, artiodactyls)	larvae, nymphs, adults	mange	-
Trombiculidae (chigger mites)	71 genera, 3,000 species	mammals, birds	larvae	skin-feeding	bacterial
Order: Astigmata [Sarcoptiformes, Acaridida] (fur/feather/itch/dust mites, lacking stigmata) [230 families, 15,000 species]					
Sarcoptidae (itch mites)	3 genera, 42 spp./ssp.	mammals	larvae, nymphs, adults	scabies, mange	-
Psoroptidae (scab mites)	20 genera, species	mammals (carnivores, ungulates)	larvae, nymphs, adults	mange	-
Listrophoridae (fur mites)	20 genera, 170 species	mammals (esp. rodents)	larvae, nymphs, adults	mange	-
Myocoptidae (fur mites)	10 genera, 70 species	mammals (esp. rodents)	larvae, nymphs, adults	myocoptic mange	-
Cytoditidae (airsac/nasal mites)	2 genera, 12 species	birds	larvae, nymphs, adults	respiratory signs	-
Knemidokoptidae (burrowing mites)	7 genera, 16 species	birds	larvae, nymphs, adults	scaly face, scaly leg	-
Laminosioptidae (quill/skin mites)	8 genera, 25 species	birds	larvae, nymphs, adults	flesh/skin lesions	-

The superorder Acariformes comprises acarines without posterior respiratory stigmata and includes two major orders of parasites: trombidiform mites (order Prostigmata) with stigmata on the gnathosoma (capitulum) or propodosoma; and sarcoptiform mites (order Astigmata) which lack stigmata and peritremes and respire through their cuticles. Over 16,000 species of prostigmatid mites have been described: many species being free-living (including most trombiculids although some have parasitic larvae); and others being obligate ectoparasites on mammals or birds. Parasitic species spend their entire lives on individual hosts, so horizontal transmission between hosts is primarily by physical contact. Prostigmatid mites are characterized by having oval-ellipsoidal bodies (sometimes vermiform) with distinctive setation, piercing chelicerae (sometimes pincer-like), unbarbed hypostomes, well-developed palps, and short legs with coxae fused to the body wall and terminal tarsi with 1-2 claws (but lacking complex pulvilli). A total of 34 superfamilies have been recognized in 4 suborders: Anystina (with 17 superfamilies); Eleutherengona (10); Endeostigmata (3); and Eupodina (4). Many members of the suborders Anystina and Eleutherengona have legs with distinctive arrangements of the terminal tibiotarsal segments referred to as the 'thumb-claw' process. Anystina mites are mostly free-living predators that occur in soil litter, vegetation and the seashore, but include some representatives that have parasitic larvae that are often large, hairy, and bright red in

coloration. Some 17 anystine superfamilies are recognized (Adamystoidea, Anystoidea, Arrenuroidea, Caeculoidea, Calyptostomatoidea, Chyzeroidea, Erythraeidea, Eylaoidea, Hydrachnoidea, Hydrovolzioidea, Hydryphantoidea, Hygrobatoidea, Labidostommatoidea, Lebertioidea, Paratydeoidea, Stygothrombioidea, Trombidoidea).

The superfamily Trombidoidea contains mites that have evolved relatively complex life-cycles involving eggs, pre-larvae, larvae, protonymphs, deutonymphs, tritonymphs and adult male and female mites. Unlike other prostigmatid mites, the pre-larvae, protonymphs and tritonymphs are calyptostatic (instars with regressive traits, such as non-functional mouthparts and/or legs), whereas the larvae are ectoparasitic on invertebrates or vertebrates, and the deutonymphs and adults are free-living predators in soils and litters. Some 11 families have been recognized (Eutrombidiidae, Johnstonianidae, Leeuwenhoekidae, Microtrombidiidae, Neothrombiidae, Neotrombidiidae, Podothrombiidae, Tanaupodidae, Trombellidae, Trombiculidae, Trombidiidae). The family Trombiculidae contains numerous species whose larval forms are important parasites of terrestrial vertebrates and man. The parasitic larval stages are commonly known as chiggers, or alternatively as harvest mites, black soil itch mites, scrub-itch mites, duck-shooters itch mites, bush mites, berry bugs, red bugs, heel-bugs, herbstmilben, akamushi, tsutsugamushi, kedani, qhapas, aoutat, lepte autumnalis, bichos colorados, coloraditos, coloradilla, niguas or tlazahuatl. They have oval bodies with feathery setae, conspicuous palps with more than 2 segments, and 3 pairs of legs often bearing claws. The larvae are transient ectoparasites that feed on invertebrate or vertebrate hosts for several days (1-2 weeks) by embedding their mouthparts in the skin causing irritation, wheals, dermatitis and intense pruritus. More than 1,500 species have been recognized and allocated to 3 subfamilies (Hemitrombiculinae, Schoengastiinae, Trombiculinae). The subfamily Trombiculinae contains 43 genera (*Acariscus*, *Aniatus*, *Aplodontophila*, *Babiania*, *Blankaertia*, *Chiroptella*, *Crotiscus*, *Elianella*, *Endotrombicula*, *Euschoengastoides*, *Eutrombicula*, *Fonseca*, *Heaslippia*, *Heaslippioides*, *Hoffmanniella*, *Hyponeocula*, *Kaasia*, *Leptotrombidium*, *Megatrombicula*, *Microtrombicula*, *Miyatrombicula*, *Multgniella*, *Myotrombicula*, *Neacariscus*, *Neotrombicula*, *Nothotrombicula*, *Novotrombiucla*, *Oaxacarus*, *Oenschongastia*, *Pentagonella*, *Phrynacarus*, *Polylopadium*, *Riedlinia*, *Speotrombicula*, *Tecomatlana*, *Trombicula*, *Trombiculoides*, *Trombigastia*, *Vanidicus*, *Vercammenia*, *Whartonacarus*, *Willmannium*, *Womersleyia*). Over 50 trombiculid species are known to attack humans and livestock causing severe pruritus, including *Eutrombicula*, *Leptotrombicula*, *Neotrombicula* and *Trombicula* spp. The larvae are opportunistic polyphagous ectoparasites that exhibit limited host specificity. While some apparently have preferred hosts, most are able to feed on many species of mammals and birds that happen to be available in particular habitats, sometimes occurring on sympatric reptiles, amphibians and insects. Several trombiculid species have also been implicated in the transmission of bacterial infections causing scrub typhus.

Parasite species	Hosts (for larval stages)	Location	Clinical signs	Distribution
<i>Eutrombicula</i> (scutum transverse rectangular to quadrate, stippled)				
<i>E. alfreddugesi</i> (chigger mite)	Carnivora: canid (dog), felid (cat); Artiodactyla: bovid (cattle); Perissodactyla: equid (horse); Lagomorpha: leporid (rabbit); Primates: hominid (human); Accipitriformes: accipitrid (red-tailed hawk, zone-tailed hawk), cathartid (black vulture); Strigiformes: strigid (ferruginous pygmy-owl, mottled owl); Serpentes: colubrid (South American sipo, Wagler's sipo, Brazilian woodland racer, Paraguay green racer, caninana); Sauria: anolid (calango-bandeira), gymnophthalmid (yellowbelly arthrosaura, Eigenmann's prionodactylus), leiosaurid (Ihering's fathead anole), phyllodactylid (turnip-tailed gecko), scincid (Paraguay mabuya, black-spotted skink, noronha skink), teiid (striped forest whiptail), tropidurid (calango); Anura: hylid (southern walking leaf frog)	skin (body parts close to grass)	irritation, pruritus, hypersensitivity	Americas, Europe
<i>E. batatas</i>	Accipitriformes: accipitrid (great black hawk); Falconiformes: falconid (crested caracara); Primates: hominid (human)	skin		Americas
<i>E. hirsti</i>	Peramelemorphia: peramelid (northern brown bandicoot, long-nosed bandicoot); Diprotodontia: macropodid (agile wallaby), phalangerid (common brushtail possum); Rodentia: murid (bush rat, fawn-footed mosaic-tailed rat, Papua grassland mosaic-tailed rat); Primates: hominid (human); Sauria: agamid (Australian water dragon)	skin		Australia
<i>E. lipovsky</i>	Primates: hominid (human)	skin		Americas

<i>E. macropus</i>	Diprotodontia: macropodid (agile wallaby, red-necked wallaby, western grey kangaroo, eastern grey kangaroo); Primates: hominid (human)	skin		Australia
<i>E. ophidica</i>	Sauria: teiid (striped forest whiptail), tropidurid (mountain calango)	skin		South America
<i>E. rara</i>	Sauria: scincid (bar-sided forest skink)	skin		Australia
<i>E. samboni</i>	Artiodactyla: bovid (cattle, sheep); Perissodactyla: equid (horse); Lagomorpha: leporid (rabbit); Primates: hominid (human); Passeriformes: turdid (common blackbird)	skin		Australia
<i>E. sarcina</i> (scrub itch mite, black soil itch mite)	Diprotodontia: macropodid (eastern grey kangaroo, wallaroo, wallaby); Artiodactyla: bovid (sheep); Perissodactyla: equid (horse); Carnivora: canid (dog); Primates: hominid (human); Passeriformes: corcoracid (apostlebird)	skin	intense irritation (plus larvae act as vectors for scrub typhus)	Australasia
<i>E. splendens</i> (chigger mite)	Carnivora: canid (dog), felid (cat); Artiodactyla: bovid (cattle); Perissodactyla: equid (horse); Lagomorpha: leporid (rabbit); Primates: hominid (human)	skin (body parts close to grass)	irritation, pruritus, hypersensitivity	North America
<i>E. southcotti</i>	Sauria: scincid (blue-throated rainbow skink, Challenger's shade skink)	skin		Australia
<i>E. thori</i>	Sauria: scincid (tree-base litter-skink)	skin		Australia
<i>E. tinami</i>	Primates: hominid (human)	skin		Europe
<i>E. tovelli</i>	Sauria: scincid (brown four-fingered skink, Challenger's shade skink, lined rainbow skink, desert rainbow skink, copper-tailed skink, bar-shouldered ctenotus), varanid (lace monitor)	skin		Australia
<i>E. tropica</i>	Sauria: scincid (Hoge's mabuya)	skin		South America
<i>E. vandiemeni</i>	Sauria: scincid (White's skink, southern grass skink, metallic cool skink, spotted skink)	skin		Australia
<i>E. wichmanni</i>	Primates: hominid (human)	skin		Asia
<i>Leptotrombicula</i> (scutum rectangular with weak shoulders, stippled)				
<i>L. akamushi</i>	Strigiformes: strigid (short-eared owl); Primates: hominid (human)	skin, nest	irritation (plus larvae act as vectors for scrub typhus)	Holarctic
<i>L. arenicola</i>	Primates: hominid (human)	skin		Asia
<i>L. deliense</i>	Rodentia: murid (black rat, bush rat, rakali, dusky field rat, giant white-tailed rat, Cape York rat, fawn-footed mosaic-tailed rat, Papua grassland mosaic-tailed rat); Dasyuromorphia: dasyurid (red-cheeked dunnart); Diprotodontia: hysiprymnodontid (musky rat-kangaroo); Peramelemorphia: peramelid (northern brown bandicoot, long-nosed bandicoot); Primates: hominid (human); Strigiformes: strigid (Indian scops-owl, reddish scops-owl, Eurasian scops-owl)	skin	irritation (plus larvae act as vectors for scrub typhus)	Asia
<i>L. fletcheri</i>	Primates: hominid (human)	skin		Asia
<i>L. fugi</i>	Primates: hominid (human)	skin		Asia
<i>L. intermedium</i>	Primates: hominid (human)	skin		Asia
<i>L. kitasatoi</i>	Primates: hominid (human)	skin		Asia
<i>L. nissani</i>	Passeriformes: artamid (black butcherbird, grey butcherbird, Australian magpie), campephagid (black-faced cuckooshrike, white-bellied cuckooshrike), corcoracid (apostlebird), corvid (Torresian crow), melephagid (moisy miner, little friarbird, silver-crowned friarbird, dusky myzomela, yellow honeyeater, yellow-spotted honeyeater, white-throated honeyeater, tawny-breasted honeyeater, blue-faced honeyeater), monarchid (leaden flycatcher, frill-necked	skin, nest		Australia

	monarch, spectacled monarch), oriolid (green oriole); pachycephalid (rufous whistler, grey shrikethrush, Arafura shrikethrush), paradisaeid (trumpet manucode, magnificent riflebird), petroicid (pale-yellow robin, eastern yellow robin), pomatostomid (grey-crowned babbler); Columbiformes: columbid (crested pigeon, Pacific emerald dove, bar-shouldered dove); Coraciiformes: alcedinid (sacred kingfisher), coraciid (Oriental dollarbird); Cuculiformes: cuculid (pallid cuckoo); Galliformes: phasianid (Indian peafowl); Podargiformes: podargid (tawny frogmouth, Papuan frogmouth); Psittaciformes: psittaculid (pale-headed rosella); Falconiformes: falconid (Australian kestrel, Nankeen kestrel, brown falcon); Strigiformes: strigid (barking owl, morepork, barn owl)			
<i>L. pallidum</i>	Primates: hominid (human)	skin		Asia
<i>L. palpe</i>	Primates: hominid (human)	skin		Asia
<i>L. pavlovskiyi</i>	Primates: hominid (human)	skin		Asia
<i>L. robustum</i>	Passeriformes: meliphagid (yellow honeyeater, yellow-spotted honeyeater, dusky honeyeater, tawny-breasted honeyeater), oriolid (green oriole), pachycephalid (grey shrikethrush, Arafura shrikethrush), petroicid (eastern yellow robin); Podargiformes: podargid (tawny frogmouth)	skin		Asia
<i>L. scutellare</i>	Strigiformes: strigid (mountain scops-owl); Primates: hominid (human)	skin, nest		Asia
<i>L. subquadratum</i>	Primates: hominid (human)	skin		Africa
<i>Neotrombicula</i> (scutum pentagonal with a shallow convex posterior margin, stippled)				
<i>N. antechinus</i>	Dasyuromorphia: dasyurid (brown antechinus); Rodentia: murid (bush rat, fawn-footed mosaic-tailed rat)	skin		Australia
<i>N. autumnalis</i> (harvest mite)	Carnivora: canid (dog), felid (cat); Artiodactyla: bovid (cattle); Perissodactyla: equid (horse); Lagomorpha: leporid (rabbit); Primates: hominid (human); Strigiformes: strigid (little owl)	skin (body parts close to grass)	irritation, allergy	Europe
<i>N. comata</i>	Dasyuromorphia: dasyurid (brown antechinus, swamp antechinus, dusky antechinus, tiger quoll); Peramelemorphia: peramelid (long-nosed bandicoot); Diprotodontia: macropodid (parma wallaby); Rodentia: murid (bush rat); Passeriformes: acanthizid (white-browed scrubwren), climacterid (white-throated treecreeper)	skin		Australia
<i>N. gemini</i>	Dasyuromorphia: dasyurid (dusky antechinus); Rodentia: murid (bush rat)	skin		Australia
<i>N. greenlyi</i>	Sauria: gekkonid (marbled gecko, Bynoe's gecko)	skin		Australia
<i>N. mackayensis</i>	Dasyuromorphia: dasyurid (brown antechinus); Peramelemorphia: peramelid (long-nosed bandicoot); Diprotodontia: macropodid (swamp wallaby); Rodentia: murid (bush rat); Primates: hominid (human)	skin		Australia
<i>N. nagayoi</i>	Primates: hominid (human)	skin		Asia
<i>N. novaehollandiae</i>	Dasyuromorphia: dasyurid (brown antechinus, swamp antechinus, dusky antechinus, tiger quoll, eastern quoll); Diprotodontia: macropodid (parma wallaby, red-necked wallaby, swamp wallaby, Tasmanian pademelon), phalangerid (common brushtail possum), potoroid (long-nosed potoroo); Peramelemorphia: peramelid (southern brown bandicoot); Monotremata: tachyglossid (short-beaked echidna); Rodentia: murid (bush rat,			Australia

	Australian swamp rat); Carnivora: canid (dog); Passeriformes: acanthizid (white-browed scrubwren)			
<i>N. pentagona</i>	Lepidoptera: papilionid (Cairns birdwing butterfly) - accidental			Australia
<i>N. thylogale</i>	Peramelemorphia: peramelid (long-nosed bandicoot); Diprotodontia: macropodid (red-legged pademelon)	skin		Australia
<i>Trombicula</i> (scutum transverse rectangular with a deeply convex posterior margin, punctate-aerolate)				
<i>T. chiroptera</i>	Chiroptera: vespertilionid (Gould's wattled bat)	skin		Australia
<i>T. dasyphloea</i>	Chiroptera: hipposiderid (Semon's leaf-nosed bat)	skin		Australia
<i>T. dewae</i>	Chiroptera: emballonurid (common sheath-tail bat)	skin		Australia
<i>T. geckobia</i>	Sauria: gekkonid (unidentified gecko)	skin		Australia
<i>T. lukoschusi</i>	Chiroptera: emballonurid (common sheath-tail bat)	skin		Australia
<i>T. mitchellensis</i>	Chiroptera: emballonurid (common sheath-tail bat), megadermatid (ghost bat)	skin		Australia
<i>T. quadriensis</i>	Dasyuromorphia: dasyurid (brown antechinus, swamp antechinus, yellow-footed antechinus); Diprotodontia: phalangerid (short-eared possum, common brushtail possum); Rodentia: murid (rakali, bush rat, giant white-tailed rat)	skin		Australia
<i>T. rugosa</i>	Rodentia: murid (common rock rat)	skin		Australia
<i>T. southcotti</i>	Diprotodontia: macropodid (short-eared rock-wallaby)	skin		Australia
<i>T. thomsoni</i>	Chiroptera: emballonurid (common sheath-tail bat), vespertilionid (Gould's wattled bat, eastern forest bat)	skin		Australia

Parasite morphology: Trombiculid mites form 4 different types of morphological stages during their developmental cycles; namely, eggs, larvae, nymphs, and adults. The eggs are dark spherical-ovoid stages measuring around 150-200 µm in diameter which often become larger and more elongated during embryonic development. The outer eggshell eventually ruptures releasing an inactive incompletely-developed larva (known as a deutovum). The deutovum grows and develops to an active hexapod larva measuring up to 300 µm which is initially deep red in colour. These larvae are the only stages in the life-cycle that are parasitic on vertebrate hosts (all other stages are free-living). Parasitic larvae (often known as chiggers) feed on host fluids and may grow up to 400-600 µm in size, usually changing colour to orange-yellow. Trombiculid genera are differentiated mainly on the basis of differences in scutum shape, leg structure (especially genu and tarsi segments), sensillae thickness (uniform or thinning distally), and chaetotaxy (patterns of setation). The body is ovoidal to ellipsoidal in shape (slightly flattened laterally) and has a small anterior gnathosoma (head) bearing prominent mouthparts flanked by a pair of palps. The palps each have 5 segments (coxa, femur, genu, tibia and tarsus) and terminate in a thumb-claw pincer (formed by a tibial claw opposing a tarsal thumb-like process). The claw may have 3 prongs (trifurcate, e.g. *N. autumnalis*) or 2 prongs (bifurcate, e.g. *E. alfreddugesi*). The palpal femur and genu each have a single seta, the tibia has 3 setae, and the tarsus bears 4-7 setae depending on the species. The biting-sucking mouthparts are well-developed and nonretractile, with a central unbarbed hypostome flanked by short segmented blade-like chelicerae. During feeding, an elongate feeding tube (stylostome or histosiphon) develops from hardened mite saliva and host tissues. Larvae do not possess respiratory organs but breath through the cuticle. In trombiculid genera of medical and veterinary significance, the larval idiosoma (body) has a single anterodorsal shield (scutum) with 4-6 plumose (feathery) setae. The scutum varies in shape from transverse rectangular to quadrate in the genus *Eutrombicula*, pentagonal with a shallow convex posterior margin in *Neotrombicula*, rectangular with weak shoulders in *Leptotrombicula*, and transverse rectangular with a deeply convex posterior margin in the genus *Trombicula*. The scutum texture varies from stippled (*Neotrombicula*, *Leptotrombicula*, *Eutrombicula*) to punctate-aerolate (*Trombicula*, not rugose as sometimes stated) and often bears small transverse annulations. A pair of simple eyes are located laterally on either side of the scutum. The ventral idiosoma bears 3 pairs of long setate legs, each composed of 6 segments (coxa, trochanter, femur, genu, tibia, and tarsus) and ending in a pair of large claws flanking a long fine empodium. Coxae I and II are contiguous with the body wall and encompass an ovate chemosensory (Claprede) organ. Genu I have one (*Neotrombicula*), 2 (*Trombicula*, *Leptotrombicula*) or 3 (*Eutrombicula*) genuala. The uropore (anus) is located subterminally and ventrally. Trombiculid larvae appear to be highly setose, with the body and legs being covered with 20-50 fine long velvet-like setae (most plumose but some smooth). Nymphs are nonparasitic free-living stages and 3 instars have been described: an inactive nymphochrysalis (protonymph); an active and predaceous octopod (8-legged) nymph (deutonymph); and an inactive imagochrysalis (tritonymph). Nymphs are oval-shaped with an anterior constriction (imparting a stout figure-of-eight shape) and they range in size from 0.8-1.2 mm in length. They have respiratory openings (stigmata) near the bases of their chelicerae and their bodies are covered in setae. Adult mites have a stout figure-of-eight shape with the 'waist-like' constriction located between the last 2 pairs of legs. They are typically reddish in colour and range in size from 1-2 mm in length. They are covered with tiny dense hairs giving them a velvet-like

appearance. They have an anterior gnathosoma bearing conspicuous mouthparts and palps. Adults are predaceous and have piercing-cutting mouthparts with long stylet-like (sometimes pincer-like) chelicerae flanking the central unbarbed hypostome. They have respiratory stigmata located near the bases of the chelicerae (like other prostigmatid mites). The lateral palps are well-developed segmented structures but lack terminal claws (apoteles). The alimentary tract comprises a tubular foregut, sacculus midgut (with caecae) and tubular hindgut (with excretory Malpighian tubules) leading to a subterminal anus. The idiosoma lacks dorsal shields and the ventral surface gives rise to 4 pairs of long setose legs, each consisting of 6 segments (coxa, trochanter, femur, genu, tibia, and tarsus) and all ending in 1-2 claws without complex pulvilli. Female mites have 2 ovaries connected by tubular oviducts to a common uterus (with accessory shell-glands) and vagina (with accessory organs for sperm receipt and storage). Male mites have 2 testes joined by tubular vas deferens to an elongate ejaculatory duct. Males produce stalked spermatophores which are taken up by females during mating.

Site of infection: Adult and nymphal trombiculid mites are free-living terrestrial predators on the eggs and larvae of other arthropods. However, their larval stages are obligate ectoparasites on a range of vertebrate hosts, including mammals (especially rodents, but also including humans), birds, reptiles and some amphibians. *Trombicula* spp. have been recorded on bats, rodents, marsupials, and humans; *Neotrombicula* spp. on carnivores, marsupials, rodents, ungulates, lagomorphs, lizards, birds, and humans; *Eutrombicula* spp. on carnivores, ungulates, lagomorphs, marsupials, rodents, birds, snakes, lizards, frogs, and humans; and *Leptotrombicula* on birds, rodents, marsupials, and humans. Larvae crawl onto vegetation and wait for hosts to brush past so they can crawl onto available skin. Once on hosts, larvae migrate over the host (sometimes for hours) exhibiting strong site preferences for attachment and feeding, often clustering together in groups. Infestations on humans usually involve soft thin skin around the ankles, behind the knees, in the armpits, over the groin, stomach (often under belts or straps) and also the hands and face. In animals, infestations often involve areas that come in contact with the ground, e.g., the head (muzzle, face, ears), limbs, interdigital areas and ventrum, although other body sites may also be infested. On dogs and cats, larvae may cluster on the ear pinnae, sometimes in the ear canals, and eyelid margins. On birds, larvae are usually found under the wings, around the vent, or on the head (on combs and wattles and around the eyes). Some species have also been shown to exhibit differences in site preferences according to the host species infested; e.g. *L. deliense* clusters on the ear fossae of rats, but on the ventral midline of tree-shrews.

Pathogenesis: While trombiculid larvae are obligate ectoparasites on vertebrate hosts, infestations on natural hosts are generally thought to be well tolerated remaining asymptomatic or subclinical, but infestations on accidental hosts often trigger allergic immune responses leading to clinical disease (termed trombiculidiasis or trombiculosis). Chigger larvae do not burrow into the skin, but pierce the epidermis using their mouthparts. They do not suck blood, but feed on tissue fluids and lymph, although a few red blood cells may be ingested during feeding. The larvae inject saliva containing digestive enzymes that cause autolysis of epidermal cells. They suck up the resultant liquefied food (lysed semi-digested cells, intracellular fluids, extracellular fluids, incl. lymph) via a tube-like structure (stylostome or histosiphon) formed by solidified saliva and hardened tissues. Larvae remain on hosts for variable periods ranging from a few hours to several days, engorging to become bright red spheres before detaching and falling to the ground. Hosts may not react to the first few bites, but mite saliva and stylostomes are irritants and lead to allergic reactions minutes to hours after the mite has fed. Bites are evident as tiny red papules, spots or welts, typically in clusters, accompanied by intense and painful pruritus, local erythema, inflammation (dermatitis) and rash formation. Large scabs may appear around bite sites and stylostomes as the salivary enzymes degrade epithelial tissues. Hypersensitivity reactions may develop in some individuals with vesicles and bullae formation. Because larvae tend to cluster together, skin lesions and host reactions can become quite extensive. Hosts attempt to relieve the discomfort by intense self-grooming (biting, licking, scratching, rubbing) which can lead to self-trauma and excoriation with lesions becoming susceptible to secondary bacterial infections. Dogs and cats may experience severe biting stress with intensely pruritic papules on the limbs, ventrum, genitalia and around the head, sometimes accompanied by mild wheal and flare reactions. Infestations may lead to alopecia, scales, crusts and scabs with moist serous or dried yellow exudates. Cattle and horses often develop irritating lesions around the face which cause them to bite, stamp and rub against objects leading to self-mutilation in heavy infestations. Birds also develop lesions around body parts coming into contact with vegetation (mainly the head and ventral surfaces) and heavy infestations in poultry may cause significant morbidity (depression, anorexia) and mortality (from starvation and exhaustion) contributing to production losses. Humans often experience transient inflammatory pustular lesions and dermatitis particularly on the hands, face and around the waistline (under belts or straps), usually seen from spring to late summer. Some trombiculid species have gained notoriety as causative agents of scrub itch, an extremely irritating and maddening affliction due to delayed host reactions to mite salivary secretions. Epidemiological investigations have linked infestations to activities associated with handling cut vegetation (e.g. during harvest), hiking and trekking through grasslands or bushlands, and contact with animals. In several countries, infestations have been associated with a summer penile syndrome involving inflammation, pruritus and erythema of the penis and scrotal skin often in boys younger than 12 years old resulting in dysuria. Microbiological studies have also implicated several *Leptotrombicula* species as vectors for rickettsial bacterial infections to humans, notably tsutsugamushi fever caused by *Orientia tsutsugamushi* (formerly *Rickettsia tsutsugamushi*) in Asia and scrub typhus caused by *Orientia australis* in Australia. These acute infectious diseases are characterized by fever, chills, headaches, myalgia, and sometimes hearing loss. The bacteria exhibit trans-stadial transmission (persisting through nymphal and adult stages) and then trans-ovarian transmission (passing from gravid females to eggs and then larvae). *Ehrlichia* and *Borrelia* spp. have also been detected in larvae collected from birds, but their role in the transmission of disease remains speculative.

Developmental cycle and mode of transmission: Trombiculid mites undergo gradual (hemimetabolous) metamorphosis whereby eggs hatch larvae which moult through several nymphal stages to form adults. Only the larval stages attach to vertebrate hosts as ectoparasites, while nymphal and adult stages are free-living predators on other arthropods. Gravid female mites lay small clutches of 1-15 eggs on leaf litter, shaded vegetation or damp well-drained soils, including pastures, grasslands, scrublands and along riverbanks. The eggshell splits after 1-2 weeks exposing the pre-larva (deutovum) which remains in the eggshell to mature for another week before emerging as a hexapod larva (or chigger). The larvae crawl onto low vegetation in their grassland or woodland habitats and remain quiescent until stimulated by air currents containing expired carbon dioxide from approaching animals. Larvae are often referred to as 'harvest mites' as they are found in significant numbers in hay and other harvested products. Depending on prevailing environmental conditions, larvae may survive for up to 30 days waiting for hosts. Upon contact, they latch onto passing hosts and crawl to their preferred attachment sites. Larvae often congregate together on vegetation so hosts often become infested by multiple larvae which then cluster at preferred attachment sites. They are ectoparasitic on a wide variety of vertebrates, including mammals (commonly small rodents, but also humans), birds, reptiles and amphibians. Trombiculid species exhibit variable host specificity, with some species infesting a narrow range of hosts while others infest a wide range of hosts (including natural, opportunistic and accidental hosts). Larvae attach to the surface of the skin and begin feeding on host fluids by secreting saliva which helps form the stylostome feeding tube. They generally feed for 3-5 days, but the feeding time may be extended up to 10 days in hosts developing severe dermal reactions. When replete, the engorged larvae detach and drop to the ground burying themselves under leaves or just below the soil. Within 3 days they enter a quiescent phase as an inactive nymphochrysalis (protonymph) before moulting to become an active octopod nymph (deutonymph). Deutonymphs are free-living predators that feed on the eggs and larvae of other arthropods for 1-2 weeks. They then enter another quiescent phase as an inactive imagochrysalis (tritonymph) for several days. The tritonymphs finally moult to form adult mites which actively crawl around in soil feeding on a variety of soft-bodied arthropod developmental stages (notably insect eggs and larvae), plant juices and decaying plant material. Adult males produce spermatophores which are used to inseminate receptive adult female mites which then begin laying 1-15 eggs each day for up to 3-5 months. Mites are most active in warm conditions and egg laying may occur year round. However, in cooler conditions, mites suspend egg production and enter partial hibernation burrowed beneath the soil. Adult females usually live for one year, generally dying in autumn. The whole life-cycle may be completed in as little as 2 months under ideal environmental conditions. Many mite species in tropical regions undergo multiple generations each year, those in subtropical regions often undergo 2-3 generations each year, while those in cooler temperate regions only undergo a single generation each year. Mites often exhibit fragmented patchy distributions (sometimes called mite islands) due to their complex ecological requirements (e.g. free-living stages requiring moist soils with plentiful food sources, and parasitic larval stages requiring a regular supply of small vertebrates).

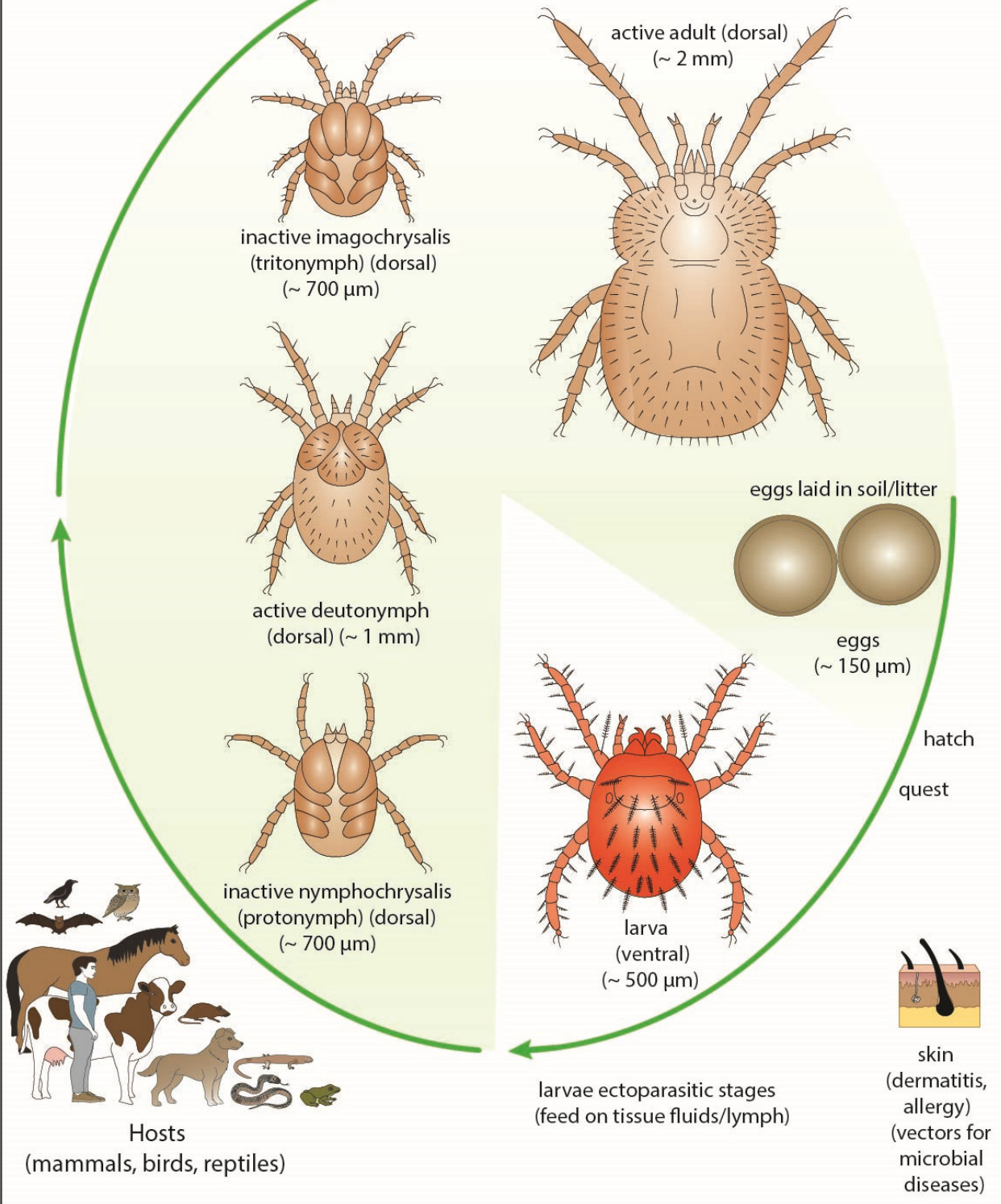
Differential diagnosis: Chigger mite infestations are difficult to detect on the basis of symptomatology as they are transient surface dwellers, easily brushed off and have often left the host when clinical signs first arise (pruritus, rash, crusting dermatosis). Nonetheless, when larvae are present, they may be observed as orange-red roundish specks (0.15-0.3 mm), usually grouped together in small clusters up to 1 mm in diameter. Specimens may be removed using probes, tweezers or swabs, examined microscopically and identified by their unique morphological characteristics. Dermoscopy has recently been used to diagnose infestations by detecting mites on the skin with strong orange-reddish fluorescence. Modern molecular biological techniques have been used to characterize trombiculid species and infer phylogenetic relationships, following the polymerase chain reaction (PCR) amplification of nuclear (internal transcribed spacers (ITS) of ribosomal RNA, citrate synthase (gltA) gene sequences. Similar techniques may also be used to screen mites for the presence of the aetiological agent of scrub typhus, namely *Orientia* (formerly *Rickettsia*) major outer membrane protein (56 kDa), chaperonin 60 (GroE1) and ribosomal RNA (16S rRNA) by conventional or nested PCR.

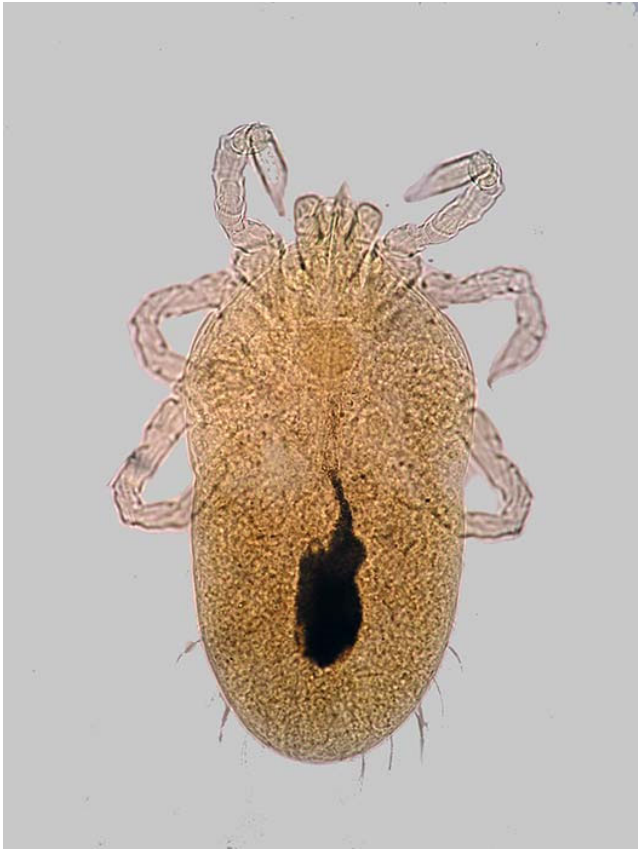
Treatment and control: While chigger mite infestations are transient and clinical signs usually resolve spontaneously, treatment is often warranted in cases where severe clinical disease develops, particularly in sensitized individuals, even though mites may have already detached. Symptomatic relief may be provided by the application of cold compresses, antipruritic lotions (e.g. calamine) or baths (e.g. Epsom salts), topical corticosteroids, and oral antihistamines. Topical antiseptics may be used to help prevent secondary bacterial infections in excoriated wounds, or patients may be given a course of antibiotics (note that hospitalization and extended antibiotic treatment may be required for cases involving scrub typhus). In situations where mites are detected still attached to the skin, they should be removed mechanically using probes or tweezers, and the affected areas washed thoroughly with soap and water. A range of chemical acaricides have been used to treat chigger mites, including sulphur compounds (lime sulphur, potassium sulphur), natural products (rotenone), carbamates (carbaryl), organophosphates (coumaphos, chlorpyrifos, malathion, diazinon), pyrethrins (permethrin) and arylpyrazoles (fipronil). Hosts resident in endemic regions are exposed to constant re-infestation during peak seasons, especially farm workers handling supplementary feeds (harvested hay, etc.). Preventing infestations may be accomplished by avoiding endemic regions, not handling cut vegetation, wearing protective clothing (boots and long-sleeved tight-fitting clothes) and applying repellents (permethrin, diethyltoluamide (DEET), dimethyl phthalate, dibutyl phthalate, dimethyl carbamate, ethyl hexanediol) to exposed skin or clothing. Studies on environmental control of chigger populations have shown that clearing vegetation (mowing, slashing, or weeding) was relatively ineffectual, but the application of residual acaricides (e.g. permethrin) as sprays or dusts to vegetation around residential premises helped lower mite populations and infestation rates. Other preventive measures involve denying larvae access to hosts by moving livestock off infested pastures, restricting pet roaming and undertaking vermin (rodent) control.

Trombicula

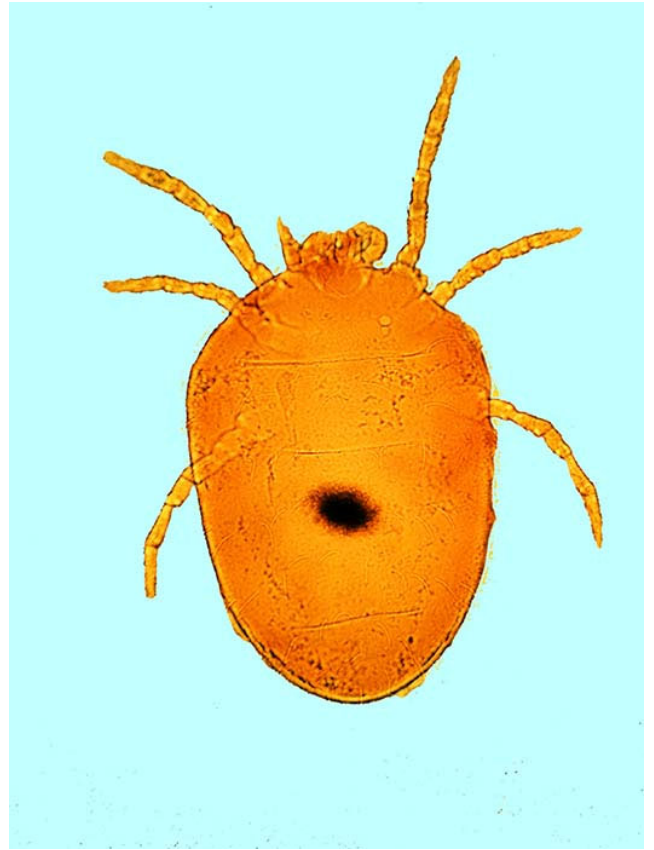
nymphs and adults free-living stages in soil/vegetation ('harvest mites')

adults and deutonymphs predatory on eggs and larvae of terrestrial arthropods

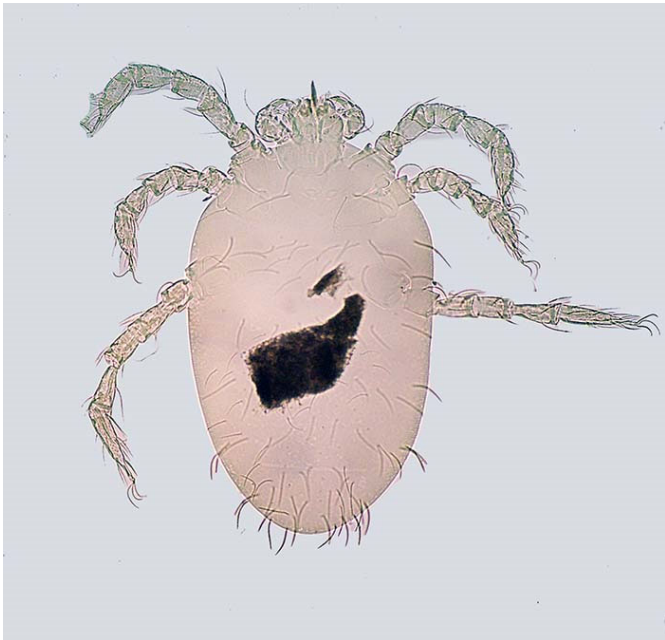




Trombicula larva



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