Raillietia
(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. Gamesid mites have anterior legs with respiratory stigmata located between the second and fourth legs. Most species are predatory, but some are ectoparasitic on mammals, birds and insects. They usually have a large sclerotized dorsal shield and a series of smaller ventral shields. Halarachnid mites are found in the respiratory tracts or ears of mammals. Infestations by *Raillietia* spp. occur in the ears of cattle and goats, but do not appear to cause clinical disease.

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:	Parasitiformes (ticks and some mites, with posterior stigmata)
Order:	Mesostigmata (gamesid mites, legs grouped anteriorly, stigmata between second and fourth legs)
Suborder:	Dermanyssina (sclerotized shields, reduced setae, legs with claws)
Superfamily:	Dermanyssoidea (elongate edentate chelicerae, diverse life-styles)
Family:	Raillietiidae (obligate parasites in ears of mammals)
Genus:	*Raillietia* (parasitic in ears of mammals)
Species:	various species cause asymptomatic infestation in cattle, goats

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 (chelicerae) 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 saccular 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 2nd & 4th 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 Parasitiformes comprises acarines with posterior respiratory stigmata and includes two major orders: the ixodid ticks (order Metastigmata) with stigmata located posterior to the legs; and the gamesid mites (order Mesostigmata) where they are located between the legs, sometimes associated with sinuous processes (peritremes). Mesostigmatid mites are further characterized by possessing unbarbed hypostomes, and long legs with free coxae (not fused to the body wall). The order Mesostigmata contains thousands of mites, with over 5,000 species recognized in 660 genera and 100 families. Nine suborders are recognized (Antennophoria, Arctacarina, Cercomegistina, Dermanyssina, Epicriina, Microgyniina, Parasitina, Sejina, and Uropodina). The suborder Dermanyssina contains robust mites with distinct sclerotized dorsal and ventral shields, reduced setae, palps with 2-tined apoteles, and legs with tarsal claws. Five superfamilies are recognized (Ascoidea, Dermanyssoidea, Eviphidoidea, Rhodacaroidea, and Veigaioidea). The superfamily Dermanyssoidea contains a diverse array of mites including free-living predators, nidicoles in the nests of vertebrates and insects, obligate and facultative ectoparasites of vertebrates and arthropods, and even respiratory and auditory endoparasites of mammals, birds, and some reptiles. The mites have elongated chelicerae (long first or second segment) with small edentate digits and concave interior margins (functioning as a tube when in opposition). A total of 11

families are recognized (Dermanyssidae, Haemogamasidae, Halarachnidae, Hirstionyssidae, Ixodorhynchidae, Laelapidae, Macronyssidae, Raillietiidae, Rhinonyssidae, Spinturnicidae, and Varroidae), many of them exclusively parasitic.

The family Raillietiidae contains unique mesostigmatid mites with robust bodies and long legs that inhabit the auditory (ear) canals of mammalian hosts. They have respiratory stigma with peritremata that extend to the level of the first coxae similar to that of other ectoparasitic Mesostigmata (whereas other parasitic mites in the respiratory tracts of birds and mammals have reduced or absent peritremata). The family Raillietiidae is monotypic and only contains one genus (*Raillietia*) with 8 described species from domestic and wild ruminants (bovids) and one marsupial host (wombat). The ear mites are not haematophagous and feed on epithelial cells and ear wax, but heavy infestations may cause blockages manifesting in vestibular disease.

***Raillietia* species**	**Hosts**	**Location**	**Clinical signs**	**Distribution**
R. acevedoi	Artiodactyla: bovid (alpine ibex)	ears		North America
R. auris (cattle ear mite)	Artiodactyla: bovid (cattle)	ears	blockage, ulceration	Americas, Eurasia, Australia
R. australis	Diprotodontia: vombatid (common wombat)	ears	subclinical	Australia
R. caprae (goat ear mite)	Artiodactyla: bovid (goat)	ears	subclinical	Americas, Europe, Australia
R. flechtmanni	Artiodactyla: bovid (buffalo, cattle)	ears		South America
R. hopkinsi	Artiodactyla: bovid (waterbuck)	ears		Africa
R. manfredi	Artiodactyla: bovid (goat)	ears		Australia
R. whartoni	Artiodactyla: bovid (kob)	ears		Africa

Parasite morphology: The ear mites *Raillietia* spp. form 4 different morphological stages during their development: eggs; larvae; nymphs (2 instars); and adult mites (immature (teneral) and mature males and females). Mite eggs are small white ovoid stages measuring around 0.5 mm in length. Larvae have white-cream ovoid bodies (idiosoma) measuring 0.5-0.7 mm long with a small anterior gnathosoma (head or capitulum) and 3 pairs of long anteroventral legs. Nymphs also have white-cream ovoid bodies with a small anterior gnathosoma. However, they are larger than larvae and measure from 0.6-1.0 mm in length and they have 4 pairs of long jointed legs. Two nymphal instars are formed: protonymphs with 3 pairs of sternal setae and a single hair on each palpal trochanter; and deutonymphs with 4 pairs of sternal setae and 2 hairs on each palpal trochanter. Protonymphs have also been observed to sometimes retain the larval exuvia after moulting. Adult mites are spherical-ovoid stages measuring from 1.0-1.5 mm in length with the idiosoma being white-cream coloured while the gnathosoma and legs are tan to reddish-brown. The small anterior gnathosoma bears the mouthparts (chelicerae and hypostome) flanked by long sensory palps. The palps have 5-6 segments (like other mesostigmatid mites) with a terminal claw (apotele), and the basal segments are fused to form a basis capitulum supporting the mouthparts. The chelicerae are long slender cutting structures with 3 segments terminating in claw-like chelae (pincers), each with a dorsal fixed digit and a ventral scythe-shaped movable digit with 3 fang-like projections. The oral opening (mouth) has a dorsal rostrum, ventral buccal cone and central unbarbed hypostome (barbed in ticks). The alimentary tract comprises the mouth (with paired salivary glands), tubular foregut (oesophagus, pharynx), saccular midgut (ventriculus branched with gastric caeca), and tubular hindgut (with excretory Malpighian tubules, and rectum) opening through the subterminal anus. The idiosoma is ovoid to sacciform in shape and usually domed in females and humped in males. It possesses small sclerotized plates (shields) located both dorsally and ventrally. The single dorsal shield covers around a third of the dorsal surface and is rhomboid to diamond-shaped with 12-34 pairs of setae ((species on ungulates have 10 podonotal pairs and 2-7 opisthonotal pairs, while the species on wombats have 19 podonotal and 15 opisthonotal pairs). There are 3 small ventral shields: a small rectangular sternal shield with a straight or slightly arched posterior margin; a narrow but well-developed genitoventral shield (most other halarachnids lack this shield) with a fringed anterior margin and a rounded posterior margin; and a small oval anal shield located around the anus. The anteroventral margin of the idiosoma has a longitudinal bifid tritosternum (lacking on other halarachnids). Adult mites have 4 pairs of long hairy legs, each composed of 6 segments (coxa, trochanter, femur, genu, tibia, and tarsus) and ending in a short pretarsus bearing a well-developed ambulacrum with paired claws and an empodium (pad-like pulvillus). Femora II have ventral processes and a pair of respiratory openings (stigmata) are located between coxae II and IV with elongate peritreme processes (whereas other halarachnids have reduced to vestigial peritremes). Adult males have 2 testes with tubular vas deferens leading to the ejaculatory duct. They have a long sheathed aedeagus (penis) which extends through the ventral genital opening (gonopore) during copulation. Female mites have paired ovaries (with ovarioles) which are connected by tubular oviducts to a common uterus (with muscular accessory shell-gland). The terminal vagina has accessory organs for sperm reception (bursa copulatrix) and storage (spermathecae) and the gonopore is a transverse slit.

Site of infection: *Raillietia* spp. are commonly known as ear mites, with *R. auris* known as the cattle ear mite, and *R. caprae* known as the goat ear mite. Larvae and adult mites are ectoparasitic in the external ear canals (including the surface of the tympanic membrane) of both domestic and wild ruminants. Infestations have been recorded predominantly from bovid artiodactylans (cattle, buffalo, goat, ibex, waterbuck, kob) and occasionally from vombatid marsupials (wombats).

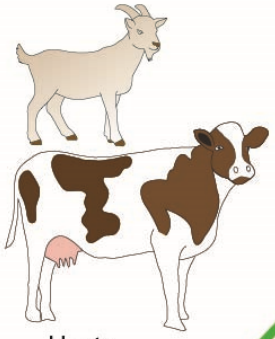
Pathogenesis: These ear mites are generally considered to be relatively harmless as larvae and adults live in the external ear canals. Although their chelicerae are adapted to lacerate epithelia, these mites do not suck blood but feed on cerumen (earwax) and cellular debris (their guts contain amber cheesy masses). Nonetheless, their claws and chelicerae damage the surface of the ear canal not only promoting cerumen production that may cause plug-like blockages but also creating sites for the invasion and multiplication of bacteria causing ear infections. The resultant cumulative effects may result in otitis media (sometimes called parasitic otitis), vestibular disease and occasionally neurological signs when the eardrum is perforated. External ear lesions may include suppurative otitis media, parakeratotic hyperkeratosis, acanthosis and inflammation of the intact tympanic membrane. Severe cases can result in ulcerated lesions as well as vestibular disease due to blockage by plugs of paste-like wax, resulting in hearing loss, head shaking and ear rubbing. Infrequently, the tympanic membranes may become perforated and mites may infest the tympanic cavity. Animals may exhibit suppurative otitis media and bulla osteitis with purulent debris, necrosis and stenosis. These changes often contribute to the development of neurological signs including ataxia, head tilting, head pressing, unilateral facial paralysis, circling, lack of coordination, and lateral recumbency with loss of righting reflex. Infestations in livestock have been associated with significant production losses through anorexia, restlessness, decreased libido, dysphagia, debilitation and emaciation. The prevalence of infestations in cattle and goats increases with age (suggesting the absence of acquired immunity) and *Bos indicus* breeds (especially Zebu) appear to be more susceptible than *Bos taurus* breeds. Ear mites may also act as biological or mechanical vectors for the transmission of various microbes to cattle, buffalo and goats, notably bacteria causing mycoplasmosis. Screening studies have detected over 28 different types of bacteria in association with mites from infested cattle, with the most common being *Proteus, Pseudomonas* and *Corynebacterium* spp. Ear infections were more prevalent in calves than in adult cows; due mainly to secondary infections with the bacteria *Pseudomonas*, *Corynebacterium*, *Escherichia*, *Haemophilus*, *Pasteurella*, *Mannheimia*, *Streptococcus*, *Mycoplasma* and *Listeria*, and the fungi *Malassezia* and *Actinomyces*. The cattle ear mite has also been associated with the transmission of a rhabditiform nematode to bovids.

Developmental cycle and mode of transmission: These mites undergo incomplete (hemimetabolous) metamorphosis whereby eggs hatch larvae which moult to nymphs and then to adults. However, not all stages occur on hosts, only larvae and adults are ectoparasitic, while nymphs (and teneral adults) are free-living on pastures. All immature stages are short-lived (survive < 2 days) whereas adults have been found to live for up to 30 days, so transmission usually occurs when teneral adults crawl into the ears of grazing hosts. Once inside the ear canal, they feed, mature and mate. Fertilized females oviposit eggs in the ear canal where they hatch releasing hexapod larvae. Studies have shown the time interval from infestation by teneral adults to the hatching of larvae to be as little as 2-4 days. Fed larvae then leave the host and drop onto pasture where they moult nymphs. Both nymphal instars (protonymphs and deutonymphs) are short-lived non-feeding stages that soon moult to form immature adults. These teneral adults wait on pastures for grazing hosts and then crawl over the pelage to enter the ears to feed and mature. Experimental studies have been able to complete the whole life-cycle in 4-8 days under favourable conditions of temperature (30°C) and relative humidity (85-90%).

Differential diagnosis: Infestations are frequently asymptomatic and therefore go undetected. Even when clinical signs become apparent (otitis, blockages), they are non-specific and may be attributable to a range of conditions (particularly bacterial infections as mites predispose hosts to secondary infections). Mites are usually detected in the ear canal by direct otoscopic examination, especially near the external opening of auditory canal. Larvae and adults are evident as small (0.5-1.5 mm) motile white spheres with legs. However, they are difficult to detect when earwax and/or pus are present as they are usually located beneath obstructive plugs. Mites may sometimes be collected by flushing the ear canal with warm water or saline or by swabbing with cotton-tipped applicators. Any specimens collected should be subject to microscopic examination for definitive identification.

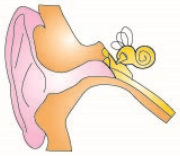
Treatment and control: The occurrence of mites deep in the ear canal makes chemotherapeutic treatment difficult, particularly since concomitant or secondary infections with bacterial and/or fungal agents may be present. Clinicians often resort to triple therapy, using antibiotics to target bacteria, acaricides to target mites and supportive glucocorticoids to relieve inflammation. Mites were eliminated by direct application of pyrethroids (flumethrin or permethrin) in mineral oil into the ear canal. Treatment efficacy was aided by prior application of saline lavages to the ear canal to loosen plugs of wax/pus. Contradictory reports have been made on the use of systemic macrocyclic lactones to control infestations, with some reporting selamectin and ivermectin to be effective, while others found them to be ineffective. There are growing suspicions that some mite populations have developed resistance particular acaricides, including ivermectin. A range of precautionary measures may be adopted in order to prevent mite transmission, involving regular health surveillance (facilitating quarantine, treatment, culling), grazing management (pasture rotation, cohort separation), environmental management (pasture spelling or cultivation, applying environmental residual acaricides, cleaning stalls and pens) and wildlife control (excluding potential reservoir hosts).

Raillietia



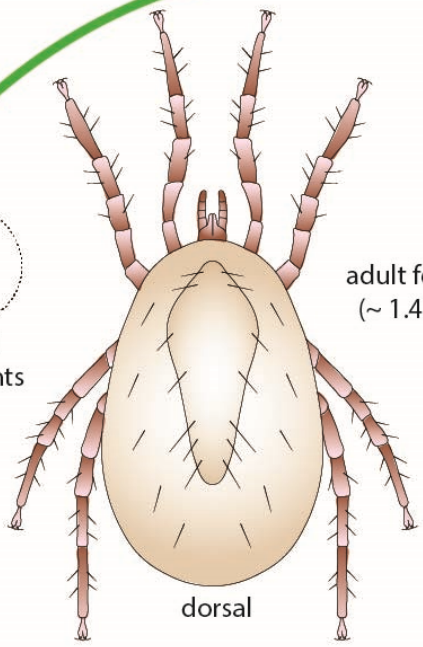
Hosts
(mammals)

transmission direct when free-living nymphs
and teneral adults seek hosts



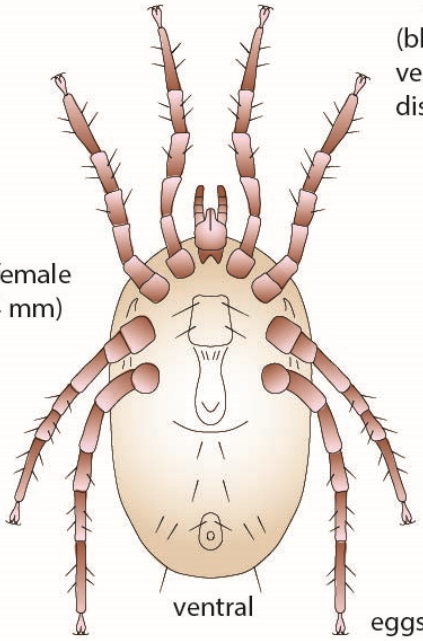
ears
(blockage,
vestibular
disease)

tarsal
elements



dorsal

adult female
(~ 1.4 mm)

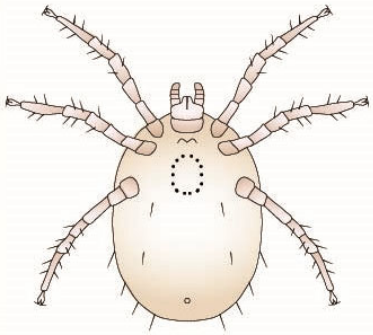


ventral

eggs laid
in ear canal

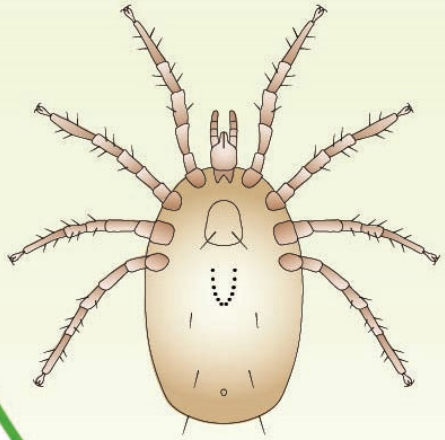
egg
(~ 500 µm)

hatch



larva
(ventral)
(~ 700 µm)

larva feed &
drop from host
when rep[lete



nymph
(ventral)
(~ 1 mm)

nymphs free-living
on pastures
[both instars (proto-,
deuto-nymphs) are
non-feeding stages)

larvae and adults are parasitic stages
(feed on epithelial cells and ear wax)

Raillietia adults