Psoroptes
(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. Sarcoptiform mites lack stigmata but respire directly through the cuticle. They have unique legs which lack claws but have terminal sucker-like modifications. They are ectoparasitic on a range of birds and mammals and may cause severe dermatitis (known as mange). Psoroptids are non-burrowing mites with oval bodies and the last two pairs of legs project beyond the body margin. Infestations by *Psoroptes* spp. may cause psoroptic mange in ruminants and ear canker in rabbits.

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:	Astigmata [Sarcoptiformes] (mange mites, without stigmata, legs separated, with suckers)
Superfamily:	Sarcoptoidea (mites associated with mammals, ecto- or endo-parasitic)
Family:	Psoroptidae (non-burrowing mites, oval bodies, third and fourth pairs of legs project beyond body margin)
Genus:	*Psoroptes* (parasitic on skin of ruminants/horses/rabbits)
Species:	various species cause psoroptic mange in ruminants and ear canker in rabbits

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 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 astigmate mites have been described in 230 families: with around 12,000 species in 154 families being free-living or predatory in terrestrial or aquatic environments (including a large assemblage of soil-dwelling oribatid mites); and some 4,000 species in 76 families occurring as commensals or parasites of arthropods and vertebrates (notably birds and mammals). Parasitic species may be ectoparasitic (on external surfaces of the host) or endoparasitic (within host epidermal or respiratory tissues) and their development often only includes 2 nymphal stages (in contrast to 3 nymphal stages in free-living species, sometimes including a specialized heteromorphic deutonymph (hypopus) adapted for phoretic dispersal or tolerance of adverse conditions). Common names for many of the parasitic groups include mange, itch, or scab mites as they may cause serious inflammatory skin conditions in their hosts.

Adult mites tend to be small, slow moving, whitish stages with soft cuticles and round-oval bodies (never vermiform) often with long setae. They possess chelate or dentate chelicerae, unbarbed hypostomes, small inconspicuous palps, legs with coxae fused to the body wall and tarsal segments bearing complex pulvilli (pad-like or trumpet-like) and empodia (claw-like or sucker-like, but never bearing tenet hairs). Most parasitic species may complete their entire life-cycles on individual hosts, so horizontal transmission between hosts is primarily by physical contact. A total of 10 astigmate superfamilies have been recognized (Acaroidea, Analgoidea, Canestrinioidea, Freyanoidea, Glycyphagoidea, Hemisarcoptoidea, Histiostomatoidea, Hypoderatoidea, Pterolichoidea, Sarcoptoidea) and an additional 2 families are currently unplaced (Cytoditidae, Heteropsoridae).

Early classification schemes identified different assemblages principally on the basis of host and site specificity; including bird-associated feather mites (e.g. Analgoidea); bird-associated skin mites (e.g. Knemidokoptidae), mammal-associated fur mites (e.g. Listrophoridae), mammal-associated skin mites (e.g. Psoroptidae); and mammal-associated skin-burrowing mites (e.g. Sarcoptoidea). However, phylogenetic studies (both cladistic and molecular) have revealed that many groups are not monophyletic but para- or poly-phyletic, so further studies are required to resolve the fidelity of most groups. Recently, molecular studies suggested that 16 sarcoptoidean families may belong to 2 main lineages: 13 families identified in a 'sarcoptid' complex (Atopomelidae, Audycoptidae, Chirodiscidae, Chirorhynchobiidae, Galagalgidae, Gastronyssidae, Lemurnyssidae, Listrophoridae, Listropsoralgidae, Myocoptidae, Pneumocoptidae, Rhyncoptidae, Sarcoptidae), and 3 families in a 'psoroptid' complex (Lobalgidae, Paracoroptidae, Psoroptidae). Nevertheless, most families can still be categorized into 4 broad 'morphoecotypes': namely; fur mites (Atopomelidae, Chirodiscidae, Listrophoridae, Lobalgidae), skin mites (Chirorhynchobiidae, Myocoptidae, Psoroptidae), skin-burrowing and follicle mites (Rhyncoptidae, Sarcoptidae), and respiratory mites (Gastronyssidae, Lemurnyssidae, Pneumocoptidae). The family Psoroptidae contains non-burrowing skin mites with oval bodies and 4 pairs of legs projecting well beyond the body margin. They are obligate mammalian ectoparasites commonly known as scab mites as their feeding activity causes dermatitis resulting in scab formation at the bite site. A total of 17 genera have been identified (*Acaroptes*, *Caparinia*, *Cheiroalalges*, *Choriopsoroptes*, *Chorioptes*, *Choriotodectes*, *Echimyalges*, *Hyracoptes*, *Listropsoralges*, *Listropsoralgoides*, *Myoproctalges*, *Nasalialges*, *Otodectes*, *Paracoroptes*, *Petauralges*, *Psorochorioptes*, and *Psoroptes*). The genus *Psoroptes* is characterized by oval mites with U-shaped genital openings and long legs lacking claws, but with long 3-jointed pretarsal stalks on most legs, and long setae on the others. While 6 species have been described from domestic animals and rabbits, recent genotypic studies revealed little inter-specific variation between *P. ovis, P. equi, P. cuniculi* and *P. cervinae*, suggesting that they may be strains of the same species (synonymized under the name *P. ovis* by precedent), but *P. natalensis* and *P. pienaari* exhibited greater variation. [Note that all 6 species are listed separately in the following table to highlight differences in other characters, such as tissue tropism, pathogenicity and distribution.]

***Psoroptes* species**	**Hosts**	**Location**	**Clinical signs**	**Distribution**
body mites				
P. equi	Perissodactyla: equid (horse, donkey, mule)	skin	psoroptic mange, otoacariasis	Australia, Europe, North and South Africa
P. natalensis	Artiodactyla: bovid (cattle, zebu, water buffalo); Perissodactyla: equid (horse)	skin (esp. legs)	mange, irritation, pruritus, papules, crusts, excoriation, lichenification	South Africa, South America, France, New Zealand
P ovis (sheep scab mite)	Artiodactyla: bovid (sheep, bighorn sheep, goat, cattle), camelid (llama, alpaca), giraffid (giraffe); Perissodactyla: equid (horse); Lagomorpha: leporid (rabbit); Primates: hominid (human)	skin (esp. legs)	mange, irritation, pruritus, papules, crusts, excoriation, lichenification	worldwide (except Australia, North America)
P. pienaari	Artiodactyla: bovid (African buffalo)	skin	mange	Africa
ear mites				
P. cervinae	Artiodactyla: cervid (deer, elk), bovid (sheep, bighorn sheep)	ears	otoacariasis, scabs	North America
P. cuniculi (ear canker mite, rabbit ear mite)	Lagomorpha: leporid (European rabbit, European hare); Artiodactyla: bovid (sheep, goat, cattle); Perissodactyla: equid (horse, donkey)	ears	mange, scabs, alopecia, excoriation, otoacariasis	worldwide

Parasite morphology: *Psoroptes* spp. form 4 different types of morphological stages during their development: namely, eggs, larvae, nymphs and adults. The eggs are ovoid translucent stages that vary considerably in size depending on the species/strain and their maturity, ranging from 70 x 50 µm for *P. cuniculi* up to 250 x 115 µm for *P. ovis*. They have been described as having an anisotropic shell surrounding central granular-flocculent material. Mature eggs hatch to release larvae with tan bodies measuring around 330 µm long. They have 6 legs arranged in 3 pairs; comprising 2 stout antero-ventral pairs (each terminating in a funnel sucker-like pulvillus) and one small postero-ventral pair (each ending in 2 long distinct setae). Larvae do not exhibit sexual dimorphism and they all have 4 pairs of dorsal setae and 9 pairs of ventral setae. The larvae moult to form nymphs which have 8 legs, having developed a fourth pair of small postero-ventral legs (each terminating in a sucker-like pulvillus and small indistinct setae). Two nymphal stages are formed: firstly, protonymphs around 400-500 µm long with 10 pairs of dorsal setae and 5 pairs of ventral setae with developing subterminal cuticular pits; and secondly, deutonymphs (sometimes called tritonymphs in early literature) around 500-700 µm long with 11 pairs of dorsal setae and 5 pairs of ventral setae with 2 well-developed cuticular pits. Female deutonymphs are readily distinguished by the occurrence of a pair of dorsal copulatory protuberances (tubercles) at the posterior end of the body. Deutonymphs moult to form adult mites which have small pearly-white to pale-brown oval bodies that are dorsoventrally flattened measuring from 0.75-2.0 mm in length. They have 2 conspicuous tagma, a small anterior head (gnathosoma or capitulum) and a larger posterior body (idiosoma). The cuticular covering appears striated with scattered setae but no spines. The gnathosoma bears prominent pointed mouthparts consisting of a pair of segmented chelicerae terminating in claw-like chelae (pincers) flanked by a pair of small sensory segmented palps (without apotele). The oral opening (mouth) is framed by a dorsal rostrum, a ventral buccal cone and a central unbarbed hypostome. The alimentary tract comprises a tubular foregut (oesophagus, pharynx), saccular midgut (ventriculus with caeca), tubular hindgut (with excretory Malpighian tubules) and rectum leading to the postero-ventral anus. The idiosoma is divided into 2 regions: an anterior podosoma bearing the legs; and the posterior opisthosoma bearing the genitalia. The idiosoma does not possess a shield-like scutum, but females mites have an anterodorsal cuticular plate behind the mouthparts and male mites have an additional larger posterodorsal cuticular plate. Like all members of the order Astigmata, respiratory stigmata are absent. The idiosoma is adorned with 10 pairs of dorsal setae (2 long pairs, 8 short pairs) and 5 pairs of ventral setae (of variable length) but most setae are long enough to protrude beyond the body margins. The ventral idiosoma bears 4 pairs of long legs which also protrude beyond the body margin and are thus visible from above. The first and second pair of legs are directed anteriorly and are well separated from the third and fourth pair which are directed posteriorly. Each leg is composed of 6 segments (coxa, trochanter, femur, genu, tibia, and tarsus), with the coxae attached to the body with distinct thickened cuticular extensions (known as epimeres or coxal apodemes). The legs lack tarsal claws and terminate in distinctive 3-jointed pretarsi comprising a long stalked pedicel ending in a complex funnel-shaped sucker (caruncle or pulvillus) on most legs (pairs I, II and III in males, I, II and IV in females) and long setae on others (cf. *Chorioptes* have smaller non-jointed pretarsi ending in cup-shaped suckers). Adult mites exhibit sexual dimorphism, with males being smaller in size than females (0.5-0.65 v. 0.6-0.8 mm) and having a pair of terminal posterior lobes bearing 4-5 setae (of varying lengths) and a pair of ventral adanal suckers (copulatory structures which engage with the copulatory tubercles of female deutonymphs). In males, the first pair of epimeres are not fused medially and the genital opening (gonopore) is U-shaped and located ventrally around the midbody. Adult males have 2 testes with tubular vas deferens leading to the ejaculatory duct and copulatory organ (sheathed aedeagus). Adult females have 2 genital suckers (replacing the copulatory tubercles seen in deutonymphs) next to the ventral vulva located between the second pair of legs. They have 2 nutrimental ovaries connected by tubular oviducts to a globular uterus where large ellipsoidal eggs can be seen developing in gravid females. The uterus is connected to a seminal receptacle and bursa copulatrix (for the receipt and storage of sperm) and an ovipositor leads to the U-shaped gonopore located mid-ventrally.

Site of infection: *Psoroptes* mites are obligative non-burrowing ectoparasites that live on the surface layers of the skin of their hosts. Some 6 species were initially recognized on the basis of variations in parasite morphology (principally chaetotaxy and male genital structures) and host occurrence (apparent host and site specificity). Four species were found on the bodies of ungulates (equids, bovids, camelids, giraffids), lagomorphs (leporids) and primates (humans), particularly along the backline but also on the neck, shoulders and flanks. Another 2 species were found in the ears of ungulates (bovids, cervids, equids) and lagomorphs (leporids). However, recent genotypic studies have suggested that most species may be strains of a single species (named after the type species *P. ovis*), which vary in morphology, host specificity, tissue tropism and pathogenicity.

Pathogenesis: Light infestations often remain asymptomatic or subclinical, but heavier infestations may cause mild to severe pruritic dermatitis in wild and domestic animals. Genotypic studies have indicated that variations in the site, intensity and severity of infestations reported on domestic animals may be due to differences in the virulence (pathogenicity) of *P. ovis* strains (with the most severe form known as sheep scab). These mites do not burrow into the epidermis but live on the surface of the skin where they feed on skin scales from the stratum corneum, superficial tissue fluids (e.g. lipid emulsions of skin cells and skin secretions), lymph and bacteria. Their mouthparts do not pierce the epidermis and they do not suck blood, but haemoglobin and other blood components may occasionally be ingested when small haemorrhages occur at abraded sites. Infestations may produce clinical disease (known as psoroptic mange) with irritation, pruritus, localized perivascular dermatitis, oedema, erythematous macules progressing to papules, crusts, scabs, yellow-orange staining of the pelage, lichenification, excoriation, alopecia and sometimes otoacariasis. Much of the skin pathology associated with infestation is thought to arise from host allergic responses (esp. type I hypersensitivity reactions) to mite antigens, particularly mite faeces. The resultant inflammation leads to surface exudation with excoriation due to host scratching/rubbing which may exacerbate small haemorrhages caused by feeding mites. This leads to skin breakage and serous

exudates which dry to form yellowish crusts, scales or scabs on the skin. Mites tend to live in the moist borders around dry crusts and they migrate outwards sometimes leading to expansive lesions. Infestations of sheep often start along the back and spread downwards leaving behind depilated, raw and scabby skin. Sheep become distressed and restless with severe pruritus, compulsive self-grooming (biting, rubbing, scratching), sometimes abnormal behaviours (nibbling, lip smacking, tongue protrusion, occasionally fits lasting 5-10 minutes), depilation/alopecia (wool loss), anaemia, reduced weight gain or weight loss, sometimes emaciation and death. Infestations may also cause exudative dermatitis in beef and dairy cattle, with lesions usually appearing on the shoulders and around base of the tail and then spreading over the body. Animals may experience intense pruritus with papular lesions leading to sticky yellowish crusts with alopecia, thickened skin, lichenification, all exacerbated by self-trauma. Persistent infestations may result in reduced meat and milk production, and predispose animals to secondary bacterial infections. Papular lesions generally develop on horses on body parts covered by thick hair (mane, forelocks, tail base) with pruritus, alopecia and thick haemorrhagic crusts and scabs. Infestations may also occur in the ear canals of sheep, goats, cattle and horses, with haematomas, scabby plugs and waxy plaques developing near the tympanic membrane causing chronic irritation, head shaking, scratching and hearing impairment (contributing to an increased risk of predation in wild animals). In rabbits, infestations generally cause ear mange (psoroptic otocariasis) with inflammatory otitis leading to ear canker typified by the accumulation of serum and brown crusts in the ear. Animals may exhibit torticollis (twisted neck) with frequent head shaking and scratching, and poor condition with weight loss and secondary bacterial infections. Epidemiological studies have shown that mite populations wax and wane seasonally, with mites being more prevalent and active over winter, but becoming fewer in number over summer and taking refuge in protected sites (axilla, groin, eyes (infra-orbital fossa), ears (inner pinnae and auditory canal), and even folds in the skin. In temperate regions, infestations often become progressively worse over time as host immune responses are compromised by sustained allergic (hypersensitivity) reactions (large numbers of regulatory T cells are recruited to the skin). Infested animals become highly prone to secondary infections causing pneumonia and septicaemia due to their altered immune status. Infestations may occur on animals of all ages but are more severe in young animals and those in poor condition. While mites do not actively infest humans, studies have suggested that exposure may produce hypersensitivity reactions is some individuals (similar to Derp1 allergen responses to house dust mites associated with some forms of asthma).

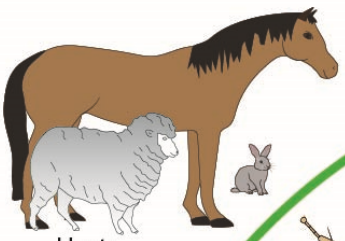
Developmental cycle and mode of transmission: *Psoroptes* mites undergo hemimetabolous (incomplete) metamorphosis where eggs hatch larvae which moult through 2 nymphal stages before forming adults. All life-cycle stages may occur on the same individual host and all motile stages feed on host tissues. Transmission occurs horizontally when mites are transferred between hosts via direct contact or via contaminated fomites as mites may survive off hosts for several days-weeks. Gravid female mites lay 1-3 eggs each day under dried crusts or scabs forming at bite sites. The eggs develop and hatch after 4 days releasing hexapod larvae which move about under the scab feeding for several days. Larvae then moult to form octopod nymphs, the first nymphal stages known as protonymphs. These stages feed for a short time and then moult to form second stage nymphs known as deutonymphs (sometimes referred to as tritonymphs in early literature). The deutonymphs also feed for a short time before moulting to form adult mites which commence feeding. Reproduction is unusual in that adult male mites attach to female deutonymphs and remain *in copula* until the females moult for the final time at which point insemination occurs. Female mites may survive for 40-60 days on the host laying up to 40-100 eggs during their lifespans. Egg production is influenced by ambient temperature with more eggs produced at lower temperatures when mites are more active over winter. The entire life-cycle may be completed in as little as 11-20 days. Transmission between animals is by contagion through direct physical contact or by fomite contamination. Mites are quite robust and may survive off hosts in cool humid conditions for 10-21 days in pieces of fleece or detached crusts/scabs attached to trees, posts, fences, chutes, trucks, etc. All life-cycle stages may be transmitted between hosts, but new infestations are only established following the transfer of gravid female mites, especially young ones. Infestations are more prevalent in areas where farm stocking densities are high, when animals are grazed intensively together and when husbandry practices muster animals frequently into close quarters. Outbreaks have been traced to lateral spread between animals in adjacent paddocks, and the co-mingling of livestock at market as well as the contamination of holding pens, shearing sheds and livestock transports.

Differential diagnosis: Psoroptic mite infestations may be indicated on clinical grounds (exudative dermatitis, pruritus, crusty-scabby lesions, alopecia), but need to be differentiated from other causes (including dermatophilosis, ring worm, pediculosis, and sarcoptic mange). Infestations are confirmed by the detection of mites in skin scrapings taken from the edges of lesions or from wax removed from the ear canals. Samples are best examined microscopically after hot potassium hydroxide digestion of skin and exudates followed by centrifugation to pellet the undigested mites. Otoscopes may also be used to detect pale adult mites moving over darker ear wax. Immunoserological tests (enzyme immunoassays) have also been developed to detect specific host antibodies in infested animals. Molecular biological techniques have also been used to characterize species and strains following the polymerase chain reaction (PCR) amplification of nuclear (ribosomal RNA, internal transcribed spacers) and mitochondrial (ribosomal RNA, transfer RNA and protein coding) genes.

Treatment and control: Clinical infestations are usually treated using chemical acaricides, either as topical (sprays, dips) or as systemic (oral, injectable, spot-on) formulations. Successful treatments have been reported using traditional lime sulphur compounds, organochlorides (lindane), organophosphates (coumaphos, phosmet, toxaphene, crotoxyphos, trichlorfon, chlorpyrifos, diazinon, propetamphos), pyrethroids (flumethrin, cypermethrin), amidines (amitraz), and more recently macrocyclic lactones (ivermectin, selamectin, doramectin, eprinomectin, milbemycin, moxidectin). Given the long survival time of mites off hosts, there

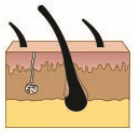
is a great propensity for re-infestation so repeated or prolonged treatments are often required. There are growing reports of acaricide resistance against some organochlorines, organophosphates, synthetic pyrethroids, and macrocyclic lactones, so it is recommended that different classes of acaricides be used in cyclic rotation to forestall the further development of drug resistance. The treatment of animals with severe crusted lesions is best expedited after they have been bathed with anti-seborrheic shampoos to loosen and remove debris. The treatment of animals with otoacariasis is also aided by cleaning the ears with ceruminolytic agents to remove waxy plugs. A range of prophylactic measures should also be adopted to prevent rapid re-infestations from other animals or from contaminated fomites. Infested animals should be isolated during treatment and animal holding facilities should be thoroughly cleaned. Acaricides with long-lasting residual activity (usually pyrethroids) may be used to spray the immediate environment to reduce off-host mite populations. Many countries have introduced legislative control programs involving compulsory stock inspections, quarantine measures and restricting stock movements, often with great success in eradication campaigns. Experimental vaccination studies conducted on rabbits, sheep and cattle have produced some measure of protection (as evidenced by reduced mite numbers and clinical signs) when animals were vaccinated with mite antigens (soluble proteins apparently more protective than membrane-bound proteins), but no commercial products have yet been produced.

Psoroptes



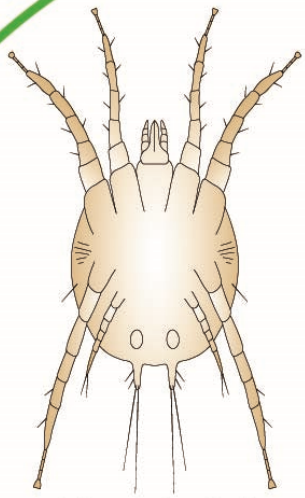
Hosts
(mammals)

transmission between hosts by close contact
or via contaminated fomites

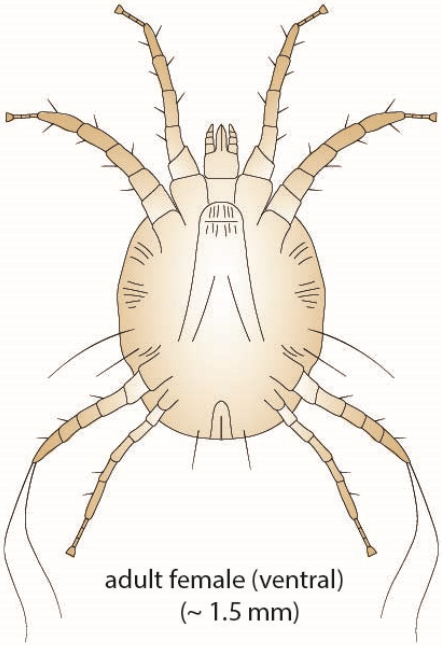


skin
(allergy,
pruritus,
dermatitis,
ear canker)

tarsal
elements



adult male (ventral)
(~ 1.2 mm)

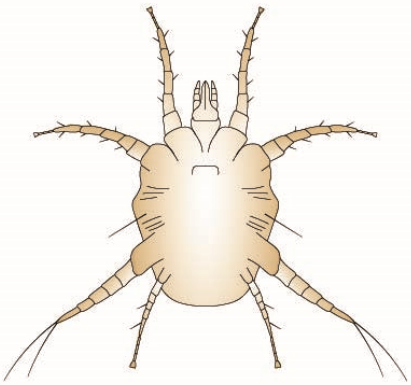


adult female (ventral)
(~ 1.5 mm)

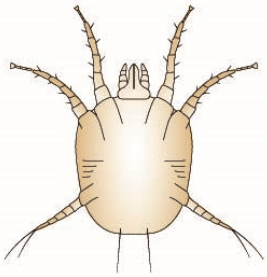
eggs laid
on skin

adult males attach to female deutonymphs
and remain *in copula* as they develop

egg
(~ 150 µm)



nymph
(ventral)
(~ 600 µm)

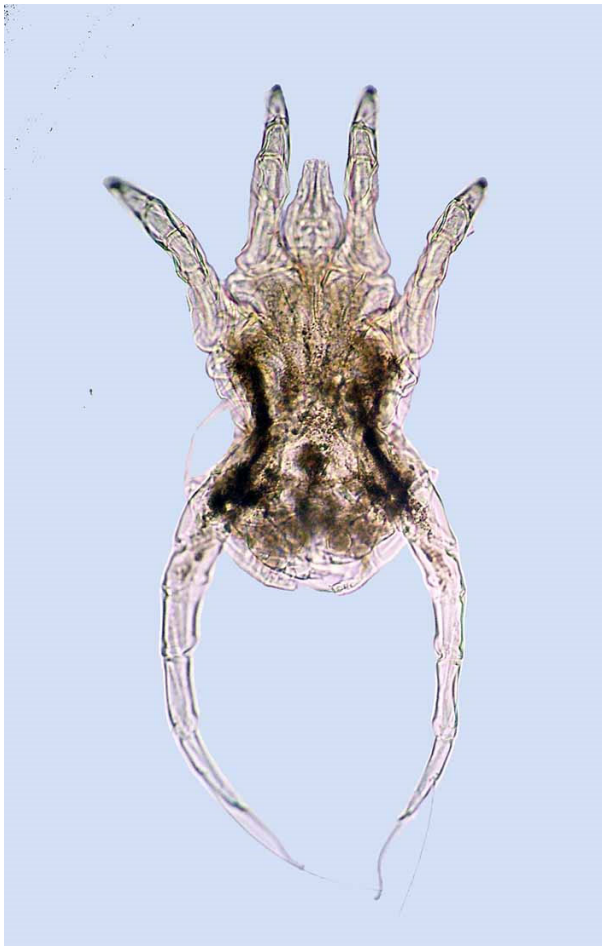


larva
(ventral)
(~ 330 µm)

hatch

2 nymphal instars
(proto-, deuto-nymphs)

all motile stages are ectoparasitic
(feed on skin scales and fluids)



Psoroptes adult

Psoroptes eggs