

Psorobia, Psorergates
(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. Psorergatid mites have circular bodies with regularly spaced legs with inward-curved spines. Infestations by the itch mites *Psorobia* and *Psorergates* spp. may cause irritation and hair loss in sheep, cattle and rodents.

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: Eleutherengona (thumb-claw process, tube-like midgut, females with adjacent anal-genital openings)
Superfamily: Cheyletoidea (chelicerate with basal stylophore and stylet-shaped movable segments)
Family: Psorergatidae (body circular, legs regularly spaced, long posterior setae, legs with inward-curved spines)
Genus: *Psorobia* (parasitic on skin of ruminants)
Genus: *Psorergates* (parasitic on skin of rodents)
Species: various species cause irritation and hair loss in sheep and cattle

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 (chelicerate) 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 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. Eleutherengone mites have simple tube-like postventricular midguts, small salivary glands (if present), females with anal and genital openings located close together posteriorly, and males with few glandular components of their testicular epithelia and accessory glands. Ten superfamilies are recognized (Cheyletoidea, Eriophyoidea, Pomerantzioidea, Pterygosomatoidea, Pyemotoidea, Pygmephorosidea, Raphignathoidea, Tarsocheyloidea, Tarsonemoidea, Tetranychosidea)

The superfamily Cheyletoidea comprises free-living predators, nidicolous forms and highly specialized ecto- or endo-parasites. Adult mites have chelicerae with basal segments fused into a single unit (stylophore), movable segments that are stylet-shaped, and the female anal and genital openings are located ventrally. A total of 8 families are recognized (Cheyletidae, Cloacaridae, Demodicidae, Harpyrhynchidae, Myobiidae, Ophioptidae, Psorergatidae, Syringophilidae). The family Psorergatidae comprises the 'itch' mites with small disc-shaped bodies with long trailing setae, dorsal shields with striated margins, and 4 pairs of legs regularly spaced around the ventral idiosoma (the legs possessing inwardly-curved spines). Three genera have been recognized: namely, *Psorergates*, *Psorergatoides*, and *Psorobia* (although some texts list them as subgenera of the genus *Psorergates*, thus causing considerable confusion with respect to species assignments). These itch mites have a conspicuous gnathosoma, palps without thumb-claw complexes, short stubby legs with pronounced hooks, and sparsely setate bodies (females with 2 pairs of long posterior setae while males only have a single pair). Some 45 *Psorergates* spp. (with smooth palp-tibial setae, and 3 pairs of setae on their dorsal shields) have been described from rodents and insectivores, 18 *Psorergatoides* spp. (with serrate palp-tibial setae, and 4 pairs of dorsal shield setae) from bats, and 10 *Psorobia* spp. (with serrate palp-tibial setae, and 5 pairs of dorsal shield setae) from a range of mammals (rodents, insectivores, lagomorphs, carnivores, primates and ungulates). The latter includes 2 notorious species, namely *P. ovis* (sheep itch mite) and *P. bos* (cattle itch mite) which impact on the livestock industries by causing psorergatic mange (dermatitis with alopecia) contributing to lost productivity.

Parasite species	Hosts	Clinical signs	Distribution
<i>Psorobia</i> (ectoparasitic on various mammals)			
<i>P. bos</i> (<i>bovis</i>) (cattle itch mite)	Artiodactyla: bovid (cattle)	occasionally alopecia, desquamation	Australia, Americas, Africa
<i>P. castoris</i>	Rodentia: castorid (American beaver)		North America
<i>P. cercopitheci</i>	Primates: cercopithecoid (grivet, white eyelid mangabey)		Africa
<i>P. elephantuli</i>	Macroscelidea: macroscelidid (North African elephant shrew)		Africa
<i>P. foinae</i>	Carnivora: mustelid (beech marten)		Europe
<i>P. hystrii</i>	Rodentia: hystricid (Cape porcupine)		Africa
<i>P. lagomorphae</i>	Lagomorpha: leporid (eastern cottontail)		North America
<i>P. mustelae</i>	Carnivora: mustelid (stoat, least weasel)		Europe
<i>P. ovis</i> (syn. <i>Psorergates</i>) (sheep itch mite)	Artiodactyla: bovid (sheep)	irritation, pruritus, scabs, wool break	Australia, Americas, Africa
<i>P. zumpti</i>	Rodentia: bathyergid (common mole-rat)		Africa
<i>Psorergates</i> (ectoparasitic on rodents and insectivores)			
<i>P. agrestis</i>	Rodentia: cricetid (short-tailed field vole)		Europe
<i>P. apodemi</i>	Rodentia: murid (wood mouse, yellow-necked mouse, Ural field mouse)		Europe
<i>P. arvalis</i>	Rodentia: cricetid (common vole)		Europe
<i>P. auricola</i>	Rodentia: cricetid (Mediterranean pine vole)		Europe
<i>P. baueri</i>	Eulipotyphla: soricid (Eurasian water shrew)		Europe
<i>P. callipides</i>	Rodentia: murid (wood mouse)		Europe
<i>P. canadensis</i>	Rodentia: cricetid (eastern meadow vole)		North America
<i>P. cinereus</i>	Eulipotyphla: soricid (cinereus shrew)		North America
<i>P. crocidurae</i>	Eulipotyphla: soricid (greater white-toothed shrew)		Europe
<i>P. cryptotis</i>	Eulipotyphla: soricid (blackish small-eared shrew)		North America
<i>P. deomydis</i>	Rodentia: murid (link rat)		Africa
<i>P. desmanae</i>	Eulipotyphla: talpid (Pyrenean desman)		Europe
<i>P. dissimilis</i>	Rodentia: cricetid (bank vole)		Europe
<i>P. doriae</i>	Eulipotyphla: soricid (Bornean shrew)		Asia
<i>P. dremomydis</i>	Rodentia: sciurid (Asian red-cheeked squirrel)		Asia
<i>P. eliomydis</i>	Rodentia: glirid (garden dormouse)		Europe
<i>P. etruscus</i>	Eulipotyphla: soricid (Etruscan shrew)		Europe
<i>P. fritzi</i>	Scandentia: tupaiid (common treeshrew)		Asia
<i>P. glaucomys</i>	Rodentia: sciurid (southern flying squirrel)		North America
<i>P. hispanicus</i>	Rodentia: murid (Algerian mouse, house mouse)		Eurasia

<i>P. mexicanus</i>	Eulipotyphla: soricid (Crawford's gray shrew)		North America
<i>P. micromydis</i>	Rodentia: murid (Eurasian harvest mouse)		Europe
<i>P. muricola</i>	Rodentia: murid (Peter's striped mouse, house mouse, wood mouse, gray brush-furred rat, tropical vlei rat)		Africa, Europe
<i>P. muscardinus</i>	Rodentia: glirid (hazel dormouse)		Europe
<i>P. musculus</i>	Rodentia: cricetid (bank vole, short-tailed field vole), murid (wood mouse)		Europe
<i>P. neerlandicus</i>	Rodentia: cricetid (tundra vole)		Europe
<i>P. oekonomi</i>	Rodentia: cricetid (tundra vole)		Europe
<i>P. oetilei</i>	Rodentia: murid (Natal multimammate mouse)		Africa
<i>P. olawaensis</i>	Eulipotyphla: soricid (lesser white-toothed shrew)		Europe
<i>P. paraxeri</i>	Rodentia: sciurid (Smith's bush squirrel)		Africa
<i>P. peromysci</i>	Rodentia: cricetid (deer mouse, white-footed mouse)		North America
<i>P. pinetorum</i>	Rodentia: cricetid (woodland vole)		North America
<i>P. pitymidis</i>	Rodentia: cricetid (Mediterranean pine vole)		Europe
<i>P. polonicus</i>	Rodentia: cricetid (European pine vole)		Europe
<i>P. quercinus</i>	Rodentia: glirid (garden dormouse)		Europe
<i>P. rattus</i>	Rodentia: murid (brown rat)		Pacific
<i>P. simplex</i>	Rodentia: murid (house mouse), cricetid (short-tailed field vole, common vole)	irritation, nodules	Europe
<i>P. sorici</i>	Eulipotyphla: soricid (common shrew)		Europe
<i>P. squamipes</i>	Eulipotyphla: soricid (Chinese mole shrew)		Asia
<i>P. talpae</i>	Eulipotyphla: talpid (European mole)		Europe
<i>P. townsendi</i>	Rodentia: cricetid (Townsend's vole)		North America
<i>P. tupaiae</i>	Scandentia: tupaiid (striped treeshrew)		Asia
<i>P. urotrichi</i>	Eulipotyphla: talpid (Japanese shrew mole)		Asia
<i>P. watsoni</i>	Rodentia: cricetid (deer mouse)		North America
<i>P. zibethicalis</i>	Rodentia: cricetid (muskrat)		Europe
<i>Psorergatoides</i> (ectoparasitic on bats)			
<i>P. artibeii</i>	Chiroptera: phyllostomid (great fruit-eating bat)		South America
<i>P. australiensis</i>	Chiroptera: vespertilionid (eastern forest bat, yellow-lipped cave bat, Arnhem long-eared bat, pygmy long-eared bat)		Australia
<i>P. desmodus</i>	Chiroptera: desmodontid (common vampire bat)		South America
<i>P. emballanurae</i>	Chiroptera: emballonurid (dark sheath-tailed bat)		Asia
<i>P. glossophage</i>	Chiroptera: phyllostomid (Pallas's long-tongued bat)		South America
<i>P. guyanensis</i>	Chiroptera: phyllostomid (dwarf little fruit bat)		South America
<i>P. hipposideros</i>	Chiroptera: hipposiderid (Sundevall's roundleaf bat, dusky leaf-nosed bat)		Africa
<i>P. indicicola</i>	Chiroptera: emballonurid (frosted sac-winged bat, greater sac-winged bat)		South America
<i>P. kerivoulae</i>	Chiroptera: vespertilionid (copper woolly bat, lesser woolly bat, wall-roosting mouse-eared bat, rufous mouse-eared bat, whiskered bat, brown long-eared bat)		Africa
<i>P. laviae</i>	Chiroptera: megadermatid (yellow-winged bat)		Africa
<i>P. lonchorhina</i>	Chiroptera: phyllostomid (Tome's sword-nosed bat), emballonurid (frosted sac-winged bat)		South America
<i>P. molossi</i>	Chiroptera: molossid (black mastiff bat, velvety free-tailed bat)		South America
<i>P. nyctali</i>	Chiroptera: vespertilionid (common noctule)		Europe
<i>P. nycteris</i>	Chiroptera: nycterid (large-eared slit-faced bat)		Africa
<i>P. peropteryx</i>	Chiroptera: emballonurid (lesser dog-like bat, chesnut sac-winged bat)		South America
<i>P. rhinolophi</i>	Chiroptera: rhinolophid (lesser horseshoe bat, intermediate horseshoe bat, greater horseshoe bat, Hildebrandt's horseshoe bat, Ruppell's horseshoe bat, Geoffroy's horseshoe bat, Mehely's horseshoe bat, Mediterranean horseshoe bat)		Africa, Europe, Asia
<i>P. surinamensis</i>	Chiroptera: phyllostomid (pygmy round-eared bat, Carriker's round-eared bat)		South America
<i>P. tadaridae</i>	Chiroptera: molossid (Malayan free-tailed bat)		Asia

Parasite morphology: Psorergatid mites form 4 different types of morphological developmental stages: eggs, larvae (one instar), nymphs (2-3 instars), and adults (males and females). Eggs are circular-oval tan stages measuring from 70-117 μm in diameter. The eggs embryonate to contain prelarval stages containing 2 small sclerotized sickle-shaped structures and a distinct gnathosoma (head) and idiosoma (body). Larvae are rounded to disc-shaped measuring 70-108 μm in diameter. They have a prominent gnathosoma protruding anteriorly and adorned with short setae. They are hexapods with 3 pairs of short stumpy legs, each composed of 2 segments with 2 terminal (3 pointed) claws. The proximal leg segments bear a basal spur, and the first 2 pairs of legs have small sensory solenidia on the apical segments. All nymph stages are octopod with 4 pairs of legs that become progressively larger and more setate with each instar. Many early reports described 2 nymphal instars (protonymphs and deutonymphs), but experimental studies revealed the occurrence of a third instar (tritonymphs) for some species. Protonymphs were rounded stages measuring 80-130 μm in diameter with 4 pairs of short stubby legs regularly spaced along each side. Deutonymphs were rounded stages measuring 120-170 μm in diameter 4 pairs of slightly longer legs located laterally, with the fourth pair shifted slightly posteriorly. Tritonymphs were pyriform stages measuring 150-200 μm long with 4 pairs of legs similar to those of adult mites. Adults were round to oval in dorsal profile but had dorsoventrally-flattened disc-shaped bodies ranging in size from 150-200 μm in length (females 170-200 μm , males 150-170 μm). The cuticle was thin, finely striate and only possessed sparse setation. However, these itch mites were characterized by the possession of long trailing whip-like setae (2 pairs in females, one pair in males), as well as short stout legs with pronounced elbow-like protuberances on middle segments. The anterior gnathosoma was small but conspicuous, containing well-developed mouthparts (chelicerae and hypostome) flanked by sensory palps. The palps contained 2 stout segments terminating not in a thumb-claw complex (apotele) but in claw-like setae (smooth in *Psorergates*, but serrate in *Psorobia* and *Psorergatoides*). The stylet-like segmented chelicerae were well adapted for piercing and cutting, being pincer-like with toothed condyles and movable digits. The mouth was formed by confluence of a dorsal rostrum, ventral buccal cone and central hypostome. The hypostome was not barbed and the antero-dorsal region formed part of the stylophore capsule. Adult mites possessed anterior respiratory openings (stigmata) located near the bases of the chelicerae (like some other prostigmatid mites), but the stigmata lacked cuticular peritremes. The alimentary tract consisted of a tubular foregut (oesophagus, pharynx), saccular midgut (ventriculus with caeca/diverticulae), tubular hindgut (with excretory Malpighian tubules) and a short rectum opening to a subterminal ventral anus. The large discoidal idiosoma bears a lightly-sclerotized dorsal shield covering most of the dorsum. The shield is punctate with striated margins and possesses 3-5 pairs of spine-like setae (3 pairs for *Psorergates*, 4 pairs for *Psorergatoides*, and 5 pairs for *Psorobia* (4 long lateral pairs, 1 short antero-median pair)). The 4 pairs of short stubby legs are regularly spaced around the ventral idiosoma, each leg consisting of 6 segments (coxa, trochanter, femur, genu, tibia, and tarsus) and terminating in 2 apical claws (with 1, 2 or 3 points) and a bilobed pad-like empodium. The coxae are fused to the body wall and often have a thickened extension (apodeme) joining them. The trochanter has a small anterior proximal spur directed downwards and the femur has a distinctive hooked appearance due to the possession of an elbow-like posteriad protuberance. Female mites have 2 ovaries (with ovarioles) joined by tubular oviducts to a globular uterus (with muscular shell-gland) and vagina with accessory organs for sperm receipt and storage (bursa copulatrix, spermathecae). The genital opening (gonopore) is located posteroventral between 2 adanal lobes. Male mites have 2 testes connected by tubular vas deferens to the ejaculatory duct and an elongate sheathed aedeagus (penis) which is unusual in that it is located dorsally and extends from the mid-body to the gonopore near the front body margin.

Site of infection: These mites are commonly known as itch mites that live on the surface and superficial layers of the epidermis. Although they are non-burrowing mites, they feed, reproduce and lay eggs in hair follicles and small pits in epidermis, with adults frequently found on the surface of the skin but larval and nymphal stages usually found within the stratum corneum. *Psorergates* spp. have been described from 4 families of rodents (mainly cricetids and murids, but also some sciurids and gliroids) and 2 families of insectivores (soricid and talpid shrews). *Psorergatoides* spp. have been described exclusively from bats belonging to 9 different families. *Psorobia* spp. have been described from a range of mammals, including artiodactylans, carnivores, primates, lagomorphs, shrews, and some specialized rodents (mole rats, porcupines, beavers). Infestations have been reported on many body locations, but mites prefer less-keratinized areas of skin, particularly around the head, neck and dorsal midline. In sheep, they are commonly found in heavily woolled areas along the flanks between the shoulders and hips.

Pathogenesis: Infestations often remain asymptomatic or subclinical and rarely cause disease in wild animals. Heavier infestations, however, may cause skin disease (known as psorergatic mange), particularly on domestic sheep, laboratory rodents and some laboratory primates. While these mites do not burrow into the skin, they may invade hair follicles and even excavate small body-sized epidermal pits. They use their piercing/cutting chelicerae to feed within the stratum corneum of skin by puncturing cell walls. They often feed on cells in the root sheath of hair follicles causing cellular hypertrophy and hyperkeratosis, sometimes disrupting neighbouring hair follicles to form nodular cysts. Female mites may also excavate small pits in the epidermis creating egg nests. Immature mites developing in these pits may enlarge them forming fluid- or keratin-filled papular lesions that often rupture causing inflammation and other host immune responses. Infestations may cause significant irritation and pruritus, especially in animals that develop hypersensitivity reactions to mite antigens, resulting in chronic dermatitis with alopecia and scaling (scurf is often seen varying from sparse white-powdery skin particles to thick white-yellow flakes). Animals attempt to relieve the irritation and pruritus by intense self-grooming with rubbing, scratching and biting causing further damage to the skin and pelt/fleece. In sheep, infestations may cause decreased wool quantity and quality, due to fleece derangement (pulled and matted wool) and wool discoloration (slightly yellowish colour), especially common along the lateral thorax, hindquarters and thighs. Infestations by sheep itch mites are particularly problematic in Merino sheep which develop hypersensitivity reactions leading to fleece derangement and

downgrading of the clip. Infestations on cattle are usually asymptomatic, but may sometimes involve mild pruritus and patchy alopecia with increased frequency of self-grooming (licking and rubbing). Several *Psorergates* spp. have been associated with clinical disease in rodents (mice and rats) involving nodule formation on the head and neck, alopecia and self-mutilation due to intense scratching. Several *Psorobia* spp. have also been found to cause mange in colonies of laboratory primates, as well as pruritus, scaly skin and multifocal alopecia in a siamang in a zoo. The clinical significance of *Psorergatoides* spp. infestations on bats is not known, but mites have been associated with dermatitis, alopecia and thickened skin on wing membranes which may affect their ability to fly and forage effectively.

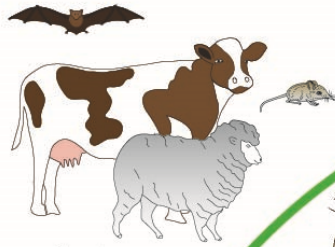
Developmental cycle and mode of transmission: Like all mites, psorergatid mites undergo incomplete (hemimetabolous) metamorphosis where eggs hatch larvae which moult to nymphs and then adult mites. Gravid females lay eggs in hair follicles and epidermal pits where they hatch after 8 days. All immature developmental stages have rudimentary legs and are not highly mobile remaining confined to the stratum corneum. Newly emergent hexapod larvae feed for several days (up to one week) before moulting to the first nymphal instar (protonymphs). These stages feed and rapidly moult to deutonymphs within a few days, and then to tritonymphs within 7 days. Tritonymphs feed and moult within a week to form adult mites which have stubby legs and are more mobile (only adults and some tritonymphs are found on the surface of skin). Adult mites feed and mate on hosts, with fertilized females producing up to 40-50 eggs over their short life-spans of around 16 days. The entire life-cycle may be completed in 35-42 days. Transmission occurs when adult mites transfer between hosts that are in close physical contact, particularly when mothers suckle their young or when animals are crowded together for extended periods. Adult mites are very sensitive to desiccation and they only survive for short periods (up to 1-2 days) when dislodged from hosts. They also do not tolerate exposure to sunlight so when sheep are shorn, adult mites often seek alternate hosts or refuges away from sunlight, thus increasing transmission rates between animals at shearing time. Nonetheless, infestations spread slowly over individuals and through flocks, taking 3-4 years to become established, and often restricted to hypersensitive individuals. Mite populations have been observed to peak during winter and decline over summer.

Differential diagnosis: Infestations in sheep may be suspected on clinical grounds, particularly when fleece derangement is involved with chewed wool on the flanks and rump. Physical examination may reveal papular lesions and scurf (dandruff) is often present as white powdery particles or yellowish flakes. Diagnoses are made by the microscopic detection of mites in skin scrapings or scurf, usually following treatment with 10% potassium hydroxide to digest skin material (mites have cuticles impervious to digestion). Biopsies may also be conducted by excising skin nodules and processing them for routine histological examination.

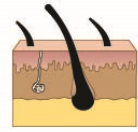
Treatment and control: It is difficult to treat psorergatic mange using conventional topical acaricides due to the location of the mites (within hair follicles and epidermal pits) and application problems (such as inadequate wetting, poor penetration, risks involved in dipping full-wooled, pregnant or young sheep, especially in cold weather). Nevertheless, some successes have been reported using sulphur preparations (lime sulphur, arsenic-sulphur), organophosphates (coumaphos, diazinon, malathion, methoxychlor), and formamidines (amitraz). Treatment efficacy was greatly improved through the use of systemic acaricides, particularly macrocyclic lactones (ivermectin, abamectin, moxidectin). The widespread use of such drenches for other endo- and ecto-parasite control has greatly reduced the incidence of itch mite infestations and disease is now considered rare. Various preventive measures may be adopted to break transmission cycles, including regular health surveillance (as a prelude to treatment, isolation or culling), routine prophylactic treatment of high-risk cohorts (laboratory animals, sheep around shearing) and maintaining hygiene around animal holding facilities (cleaning pens/stalls/yards, and replacing bedding/nesting materials).

Psorobia

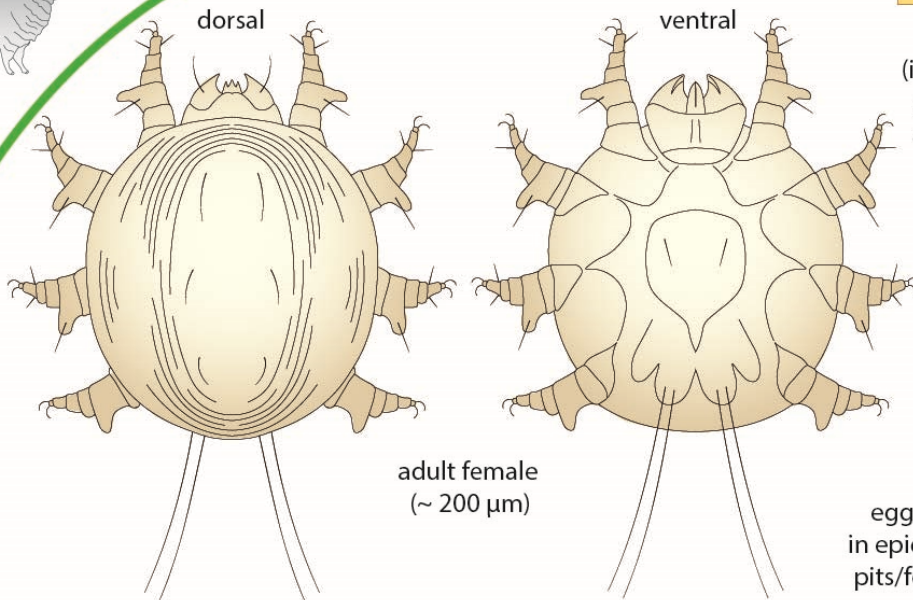
transmission between hosts by close contact
and possibly by contaminated fomites



Hosts
(mammals)

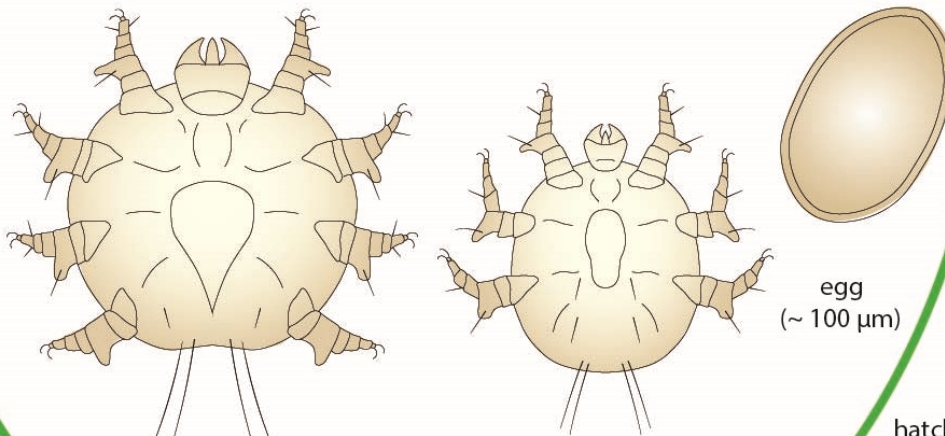


skin
(irritation,
pruritus,
alopecia)



adult female
(~ 200 μ m)

eggs laid
in epidermal
pits/follicles



egg
(~ 100 μ m)

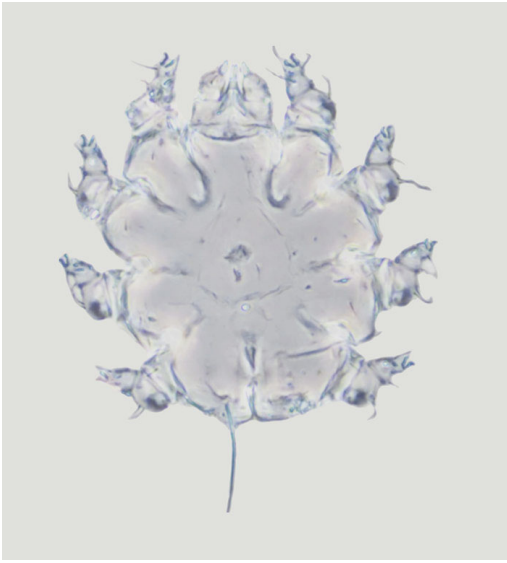
hatch

3 nymphal instars
(proto-, deuto-
& trito-nymphs)

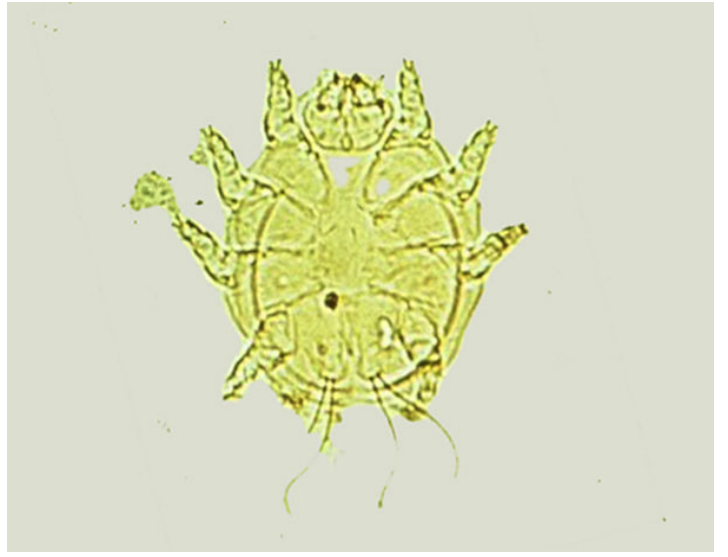
nymph
(ventral)
(~ 200 μ m)

larva
(ventral)
(~ 100 μ m)

all motile stages are ectoparasitic
(feed on dermal tissues, esp. in follicles)



Psorergates adult from rodent



Psorobia adult from sheep