

Leporacarus
(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). Linstrophorid mites have a distinct dorsal shield and their legs are modified for grasping hairs of fur-bearing mammals. Infestations by *Leporacarus* spp. are found on the skin of rabbits and hares where they may cause dermatitis and pruritus.

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: Linstrophoridae (parasitic on fur-bearing mammals, distinct dorsal shield, legs modified for grasping hairs)
Genus: *Leporacarus* (parasitic on skin of rabbits/hares)
Species: several species cause dermatitis and pruritus 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 (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 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 astigmatid 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 astigmatid superfamilies have been recognized (Acaroidea, Analgoidea, Canestrinioidea, Freyanoidea, Glycyphagoidea, Hemisarcoptidea, Histiostomatoidea, Hypoderatoidea, Pterolichoidea, Sarcoptidea) and an additional 2 families are currently unplaced (Cytoditidae, Heterosporidae).

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. Sarcoptidea). 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 sarcoptoid families may belong to 2 main lineages: 13 families identified in a ‘sarcoptid’ complex (Atopomelidae, Audycoptidae, Chirodiscidae, Chirorhynchobiidae, Galalgidae, Gastronyssidae, Lemurnyssidae, Listrophoridae, Listropsoralgidae, Myocoptidae, Pneumocoptidae, Rhyncoptidae, Sarcoptidae), and 3 families in a ‘psoroptid’ complex (Lobalgidae, Paracoptidae, Psoroptidae). Nevertheless, most families can still be categorized into 4 broad ‘morphocotypes’: 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 Listrophoridae comprises small elongate mites with palps and legs modified for grasping hairs in a wide variety of fur-bearing mammalian hosts. Some 26 genera have been recognized: namely, *Aeromychirus*, *Afrolistrophorus*, *Asiochirus*, *Carnilistrophorus*, *Centetesia*, *Chirodiscoides*, *Cryptocoptes*, *Echinorella*, *Eurychiroides*, *Geomylichus*, *Hemigalichus*, *Indochirus*, *Lemuroecius*, *Lemuroptes*, *Leporacarus*, *Listrophorus*, *Lynxacarus*, *Metalistrophorus*, *Olistrophorus*, *Prolistrophorus*, *Pteromychirus*, *Quasilistrophorus*, *Schizocarpus*, *Sclerolistrophorus*, *Spalacarus*, and *Tenrecobia*. The genus *Leporacarus* (syn. *Listracarus*) contains stout mites with flat ventral surfaces possessing expanded coxal fields with grooved surfaces to aid in host attachment. Male mites possess large adanal clasping organs, seen as parallel rectangular protrusions extending well beyond the posterior margin of the body. Four species have been described from rabbits (domestic and wild) and hares, occasionally causing moist dermatitis and alopecia.

| <i>Leporacarus</i> species | Hosts | Location | Clinical signs | Distribution |
|-------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|----------------|-------------------------------|
| Subgenus <i>L. (Leporacarus)</i> | | | | |
| <i>L. (L.) gibbus</i> (syn. <i>Listrophorus gibbus</i>) | Lagomorpha: leporid (European hare, Cape hare, European rabbit, black-tailed jackrabbit); Rodentia: murid (black rat); Carnivora: felid (cat); Primates: hominid (human) | hair | mange | Africa, Europe, North America |
| Subgenus <i>L. (Leporacaroides)</i> | | | | |
| <i>L. (L.) brevicaudatus</i> | Lagomorpha: leporid (European hare, mountain hare) | | | Europe |
| <i>L. (L.) leporicolus</i> | Lagomorpha: leporid (scrub hare); Carnivora: viverrid (common slender mongoose) | | | Africa |
| <i>L. (L.) sylvilagi</i> | Lagomorpha: leporid (brush rabbit, cottontail rabbit) | | | North America |

Parasite morphology: *Leporacarus* spp. have been shown to form 4 different types of morphological stages during their development; namely, eggs, larvae, nymphs (2 instars) and adult mites (males and females). The eggs are elongate ellipsoid measuring around 210 x 80 µm and are flattened along one side. They are attached to host hairs at one pole by proteinaceous secretions such that the egg lies tangential to the hair shaft. Mature eggs hatch by splitting down the dorsal midline, leaving empty egg cases with a 2-winged appearance. Larvae are oval in dorsal view, but flattened ventrally and curved (hunched) dorsally. They range in size from 200-300 µm in length and have 3 pairs of ventral legs, 2 anterior pairs projecting forwards and a midbody pair projecting backwards. The first pair of legs have clasping membranous flaps used to attach to host hairs (these characteristic flaps persist throughout subsequent mite development). Nymphs are similar in shape and configuration to larvae, but are larger (measuring 300-500 µm) and now have 4 pairs of legs (having developed another pair of posterior legs). Two nymphal stages are thought to occur: protonymphs and deutonymphs (the latter sometimes called teleonymphs as they have most characteristics of adult female mites but have immature genital structures). Adult mites (both males and females) have oval-subcylindrical bodies that are flattened laterally, flattened ventrally and curved dorsally. They are tan-brown in colour and range in size from 400-610 x 200-350 µm. Adults have 2 main tagma: a small anterior sclerotized gnathosoma (head) with a rounded dorsal protrusion that extends slightly beyond the mouthparts imparting a dark hooded appearance, and a large posterior idiosoma (body) with a transparent cuticle bearing distinct transverse striations (in thumbprint patterns). The gnathosoma had a basis capitulum with ventral hood-like claspers,

mouthparts comprising a pair of 3-segmented chelicerae terminating in claw-like chelae, and a pair of small flanking sensory palps (without terminal apoteles) pressed against the central unbarbed hypostome. The capitular claspers and cheliceral chelae are adapted for grasping hairs and have been described by some as chitinous lips. The alimentary tract comprises a tubular foregut (oesophagus, pharynx), saccular midgut (ventriculus with caeca) and tubular hindgut (with excretory Malpighian tubules) opening to a subterminal anus. The idiosoma possesses a distinct dorsal propodonal shield whose pre- and post-scapular portions are separated by a small suture in males but fused in females. Like all Astigmata, respiratory stigma and tracheae are absent as the mites breathe through their cuticles. The ventral idiosoma gives rise to 4 pairs of legs arranged in 2 fields: 2 anterior pairs and 2 posterior pairs, but all legs extending well beyond the body margin. Each leg has 6 segments (coxa, trochanter, femur, genu, tibia, and tarsus) with the coxae fused to the body wall and having expanded flat anterior fields (wider than long) with thickened grooved apodemes (or epimeres) that join to form a Y-shape for the first pair of legs and a V-shape for the second pair of legs. Most distinctively, the coxae of the first pair of legs each have 2 striated clasping membranous flaps used to attach to hairs. All legs have tarsal setae and all legs terminate in sucker-like caruncles (short pretarsal stalks with cup-like pulvilli). Adults display considerable sexual dimorphism with males being smaller than females (400-510 x 200-330 v. 450-610 x 250-350 μm) and bearing 2 round adanal suckers and 2 rectangular posterior processes with long caudal setae (clasping organs imparting a unique 'double-tail' appearance). Adult males have 2 testes with tubular vas deferens leading to an ejaculatory duct and long sheathed aedeagus (penis) which is surrounded by fused prescapular (pregenital) sclerites. Female mites have a more hunched appearance with rounded posterior ends. They have 2 ovaries with tubular oviducts leading to a globular uterus (with shell glands) and vagina (with accessory organs for sperm reception (bursa copulatrix) and storage (spermathecae)) opening to a rounded terminal gonopore.

Site of infection: These non-burrowing fur mites are found on the hairs of the dorsum and abdomen mostly on lagomorphs (wild and domestic leporids) and occasionally on a few rodents (murids), carnivores (viverrids) and rarely on primates (humans).

Pathogenesis: Most infestations are well tolerated by their hosts and often remain asymptomatic (to the extent that the mites were initially considered to be commensals), but heavier infestations have been associated with a mild clinical disease characterized by dermatitis with alopecia. It has been suggested that disease expression is the result of allergic/hypersensitivity reactions to the presence of feeding mites and their secretions (saliva) and excretions (faeces). Mites are surface dwellers which attach to host hairs and feed on sebaceous secretions (sebum), epithelial cells, skin and hair scales and other debris. Infestations have been associated with pruritus, moist dermatitis, erythema, seborrhoea, mild scurfing and scaling (not pronounced like cheyletiellosis), poorly demarcate alopecia, abnormal moulting and self-trauma due to biting, scratching or rubbing, normally around the rump area. Heavy infestations may give the coat a salt-and-pepper appearance, especially when wet. The exuviae (cast 'skins') of immature stages (eggs, larvae and nymphs) remain attached to host hairs contributing to the speckled appearance of infested (or previously infested) areas. Clinical infestations are more common on long-haired rabbits, young animals and those with underlying problems that interfere with grooming (including obesity, spinal disorders, dental conditions and other debilitating diseases). *Leporacarus* mites have also been associated with transient dermatitis and papular urticaria in humans, usually those regularly handling infested animals.

Developmental cycle and mode of transmission: These fur mites undergo hemimetabolous (gradual or incomplete) metamorphosis in that eggs hatch larvae that moult to nymphs and then adults. All life-cycle stages may occur on the same individual host, and transmission between hosts appears to occur by direct contact or possibly via contaminated fomites. Few details are known about the dynamics and kinetics of the life-cycle, but field observations and laboratory studies have shown that gravid females attach eggs singly to hair shafts where they hatch in several days to release hexapod (6-legged) larvae. The larvae moult through 2 octopod (8-legged) nymphal instars several days apart before finally moulting to adult male and female mites. All immature developmental stages moult while attached to hairs using clasping parts of their mouthparts as well as the clasping membranous flaps associated with the coxae of the first pair of legs. Movement along and between hairs is achieved using their remaining pairs of legs. Larval and nymphal exuviae (cast exoskeletons) usually remain attached to hairs after moulting. Adult mites mate on their hosts and gravid females begin ovipositing eggs on hair shafts. The whole life-cycle may be completed in 14-20 days but may take longer in unsuitable conditions due to apparent delayed development or diapause. Field studies conducted on hares suggested that infestations exhibited seasonal changes, with summer populations being 'generative' (with slower development, nymphal diapause, and prolonged life-spans) and winter populations being 'vegetative' (with accelerated development and shorter life-spans).

Differential diagnosis: Any clinical signs exhibited by animals are usually mild, generally involving moist dermatitis with patchy alopecia. They are nonspecific and may be attributed to a range of conditions, including microbial infections and other ectoparasites as well as diseases caused by stress, allergies, nutritional deficiencies and other skin conditions. Definitive diagnosis is made by the direct demonstration of mites on hosts. Visual examination may reveal the presence of mites in the pelage, often evident as small dark specks moving away from light, particularly noticeable on hosts with light-colored coats. Antemortem samples may be collected for microscopy by vacuum aspiration, hair plucks (trichograms), brushing or combing the fur, or by sticky-tape impressions (skin scrapings are inappropriate for these surface-dwelling mites). Postmortem samples may also be collected by placing bodies or pelage samples in bags or dishes and collecting any stages that migrate to the tips of hairs as the samples cool down. Mites can be

readily identified microscopically by their characteristic morphological features, especially adult male with their unique posterior clasping organs. Molecular biological techniques have recently been used to characterize species by polymerase chain reaction (PCR) amplification of mitochondrial gene sequences (cytochrome oxidase I).

Treatment and control: Infestations by fur mites have been successfully treated using conventional topical acaricides (dusts, sprays, baths) as well as more contemporary systemic preparations (oral, injectable or spot-on formulations). Early treatments involved sulphur-based compounds, paraffin oil, organophosphates (diazinon), carbamates (carbaryl), benzoic esters (benzyl benzoate) and synthetic pyrethroids (deltamethrin, permethrin), which have now largely been superseded by neonicotinoids (imidacloprid), amidines (amitraz) and macrocyclic lactones (ivermectin, eprinomectin, doramectin, selamectin, moxidectin, abamectin). Attention should be paid to any drug contra-indications as some formulations may have serious adverse side-effects (e.g. fipronil may cause depression, anorexia, seizures and death in rabbits). If bathing the animal is required, care should be taken to reduce the risks of hypothermia (warm bath, towel dry, provide supplemental warmth using heat lamps). Some clinicians have also found that animals may benefit from the use of non-acaricidal chemicals (cleansing agents, antifungals or anti-inflammatories) commonly used to treat seborrhea (the reduction in skin keratin and sebum content provides unsuitable conditions for feeding mites). Various preventive measures have also been adopted to help break putative transmission cycles, involving regular health surveillance (monitoring to facilitate treatment, isolation and quarantine), animal husbandry (avoid over-crowding in holding and nursing facilities), improved sanitation (cleaning cages/pens/hutches, applying residual acaricides such as methoprene/permethrin sprays to cracks/crevices and porous fomites such as carpets), and wildlife management (excluding wild animals from farms, stores, breeding centres and households).

Leporacarus

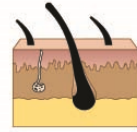
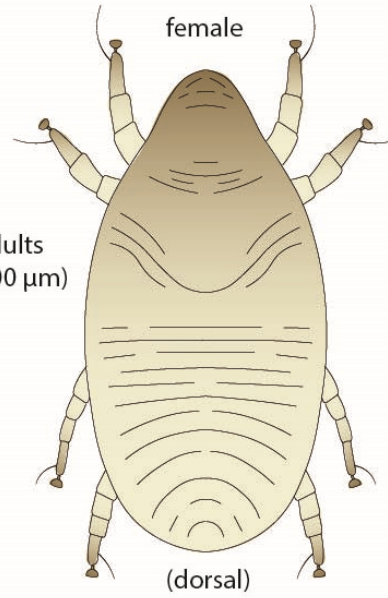
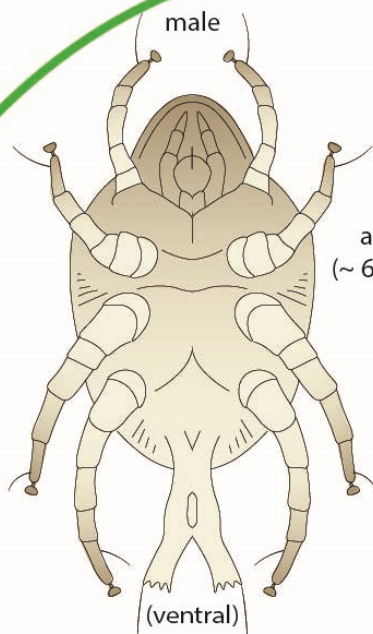
transmission between hosts by close contact
or via contaminated fomites



Hosts
(lagomorphs)



tarsal
elements



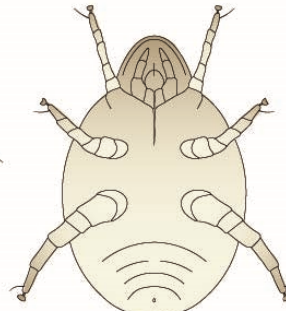
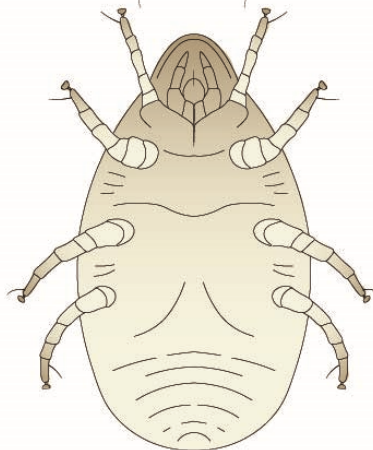
skin
(pruritus,
dermatitis,
alopecia)

eggs attached
to pelage



egg
(~ 200 μm)

hatch



2 nymphal instars
(proto-, deuto-nymphs)

all motile stages are ectoparasitic
(attach to hairs and feed on sebum, skin scales)



Leporacarus adult male