Lynxacarus
(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). Listrophorid mites have a distinct dorsal shield and their legs are modified for grasping hairs of fur-bearing mammals. Infestations by *Lynxacarus* spp. may cause unkempt coats and pruritus in cats.

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:	Listrophoridae (parasitic on fur-bearing mammals, distinct dorsal shield, legs modified for grasping hairs)
Genus:	*Lynxacarus* (parasitic on skin of cats)
Species:	various species cause unkempt coats and pruritus in cats

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 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*, *Echinosorella*, *Eurychiroides*, *Geomylichus*, *Hemigalichus*, *Indochirus*, *Lemuroecius*, *Lemuroptes*, *Leporacarus*, *Listrophorus*, *Lynxacarus*, *Metalistrophorus*, *Olistrophorus*, *Prolistrophorus*, *Pteromychirus*, *Quasilistrophorus*, *Schizocarpus*, *Sclerolistrophorus*, *Spalacarus*, and *Tenrecobia*. The genus *Lynxacarus* (syn. *Felistrophorus*) comprises robust mites with striated bodies that are flattened ventrally so that their sternal plates accommodate host hairs. A total of 16 species have been described predominantly from carnivores, rodents and some insectivores. Several authorities have recognized 3 subgenera: namely, *L.* (*Lynxacarus*) with 3 species, *L.* (*Dubininetta*) with 4 species, and *L.* (*Lutracarus*) with 2 species (the remaining species being unplaced). The species *L. radovskyi* is considered to be mildly pathogenic in cats (particularly ferals/strays) in tropical and subtropical regions, with infestations producing unkempt coats and inciting excessive grooming with regurgitative sequalae (vomiting, hairballs).

***Lynxacarus* species**	**Hosts**	**Location**	**Clinical signs**	**Distribution**
Subgenus *L.* (*Lynxacarus*)				
L. (*L.*) *morlani*	Carnivora: felid (bobcat)			North America
L. (*L.*) *mustelae*	Carnivora: mustelid (river otter, least weasel, long-tailed weasel, European polecat, stoat, European pine marten, beech marten, European badger)			Europe, North America
L. (*L.*) *nearcticus*	Carnivora: mustelid (American mink, European mink, long-tailed weasel); Rodentia: sciurid (chipmunk)			North America
L. (*L.*(*radovskyi* (cat fur mite)	Carnivora: felid (cat)	hair	dull unkempt coat, pruritus, excessive grooming, vomiting, hairballs, anorexia	North America, Australia, Pacific Islands
L. (*L.*) *serrafreirei*	Carnivora: mustelid (lesser grison)			South America
Subgenus *L.* (*Lutracarus*)				
L. (*Lu.*) *canadensis*	Carnivora: mustelid (river otter)			North America
L. (*Lu.*) *visoni*	Carnivora: mustelid (American mink)			North America
Subgenus *L.* (*Dubininetta*)				
L. (D.) *dubinini* (syn. *Dubininetta*)	Eulipotyphla: talpid (Russian desman, Pyrenean desman, Japanese mole)			Eurasia
L. (*D.*) *echinosorex* (now *Echinosorella*)	Eulipotyphla: erinaceid (moonrat)			Asia
L. (*D.*) *taiwanensis* (syn. *Dubininetta*)	Eulipotyphla: talpid (insular mole)			Asia
L. (*D.*) *talpae* (syn. *Dubininetta*)	Eulipotyphla: talpid (long-nosed mole)			Asia
Unplaced				
L. grandior	Rodentia: murid (mountain giant Sunda rat)			Asia

L. lyncodon	Carnivora: mustelid (Patagonian weasel)			South America
L. palawanensis	Scandentia: tupaiid (Palawan treeshrew)			Asia
L. semnopitheci	Carnivora: viverrid (Asian palm civet); Scandentia: tupaiid (Horsfield's treeshrew); Primates: cercopithecid (Hose's langur, Paitan langur)			South-East Asia
L. tupaiae	Scandentia: tupaiid (common treeshrew, northern treeshrew, mountain treeshrew)			Asia

Parasite morphology: *Lynxacarus* spp. form 4 different types of morphological developmental stages: eggs, larvae, nymphs and adults. The eggs are elongate ellipsoidal stages ranging in dimensions from 200-250 x 80-100 μm and they have rounded tapering poles and are slightly flattened along one side (the side they are attached to host hair shafts). Larvae have elongated oval bodies measuring from 200-300 μm in length with a flattened ventral surface giving rise to 3 pairs of legs (the first 2 pairs projecting forwards, the third pair projecting backwards). Larvae, like all subsequent nymphal and adult stages, are equipped with sternal plates that partly encircle host hairs, and together with the first two pairs of legs allow the mites to move like monorails along the hair shafts. It is thought that 2 nymphal instars occur, protonymphs and deutonymphs, ranging from 300-515 μm long, both stages with elongate flattened bodies with 4 pairs of ventral legs. They are generally similar in morphology to adult female mites but are smaller, lack propodosomal plates, and have shorter legs and fewer setae. Adult mites have characteristic elongate narrow bodies that are somewhat cylindrical but laterally compressed, flattened ventrally and arched dorsally. They range in size from 350-530 μm long by 95-125 μm wide, with females being larger than males (420-530 x 120-125 cf. 350-450 x 95-110 μm). They have 2 main tagma: a small anterior gnathosoma (head) with a well-developed head plate that is often light-dark brown in colour and ventrally directed, and a long posterior idiosoma (body) that is transparent white-tan with a strongly-patterned cuticle (numerous transverse striations). The gnathosoma has short mouthparts comprising a pair of segmented chelicerae terminating in claw-like chelae arising from a basis capitulum flanked by a pair of sensory palps (the chelae are adapted for grasping hair shafts between the basis capitulum and palps). The oral opening (mouth) has a dorsal rostrum, ventral buccal cone and unbarbed hypostome. The alimentary tract consists of a short tubular foregut (oesophagus, pharynx), saccular midgut (ventriculus with caeca), and short tubular hindgut (with excretory Malpighian tubules) opening to a terminal anal pore (flanked by caudal lobes and anal suckers only in males only). Like all Astigmata, respiratory stigmata and tracheae are absent as the mites breathe through their cuticles. The striated idiosoma is sparsely setate but has long caudal setae (longer in males) and distinct dorsal and ventral plates. The dorsal propodosomal plates are well developed (with some species having an anterior bridge-like projection to the head plate), and the propodonotal plates have pre- and post-scapular portions separated by small strip of striated cuticle. Adult male mites also have lateral opisthosomal plates (lacking in females). Ventrally, adult mites have sternal plates with curved flap-like extensions used with the legs to help encircle hair shafts. All adults have 4 pairs of short hooked legs clustered on the anterior two-thirds of the body, 2 pairs projecting forwards and 2 pairs backwards. Each leg comprises 6 segments (coxa, trochanter, femur, genu, tibia, and tarsus) with the coxae fused to the body wall (coxae I may be fused to the head plate) and the anterior coxal fields expanded and flattened (longer than wide) with thickened grooved surfaces (apodemes) for attachment. The femurs often have dorsal preapical prominences, the tarsi have short setae, and all legs terminate in sucker-like feet (short pretarsal stalk with spearhead-like pulvilli). Male mites have enlarged hindlegs and a tapering posterior end, cleft medially with two lobular processes bearing long slender lateral setae. Males have 2 testes with tubular vas deferens leading to the ejaculatory duct and a long rod-like aedeagus (penis) with the genital apparatus opening ventrally between coxae 4. Female mites have rounded posterior ends (without lobes or suckers) but with several setae around the terminal anus. They have 2 ovaries with tubular oviducts leading to a globular uterus (with shell glands) and vagina (with large accessory organs (bursa copulatrix, spermathecae) for sperm reception and storage) opening to a ventral midbody gonopore.

Site of infection: These non-burrowing fur mites are found attached to hairs of small mammalian hosts. Some 16 species have been described mainly from carnivores (felids, mustelids, viverrids), but also from some rodents (sciurids, murids) and several other small mammals (treeshrews, moles, moonrats and langurs). Infestations are commonly found on the perineum, around the anus, on the tail and the lateral hindlimbs, but may sometimes extend over the dorsum and rarely the whole body.

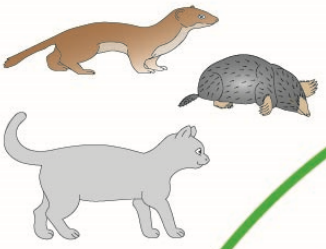
Pathogenesis: Infestations vary greatly in the number of parasites and their clinical impact, ranging from light inapparent infestations to mild infestations causing some pruritus to heavy infestations causing marked discomfort and generalised maculopapular exfoliative dermatitis (scurfy mange). Mites feed on the keratin of the hair and sebaceous skin secretions and often cause little harm. However, the presence of mites can lead to dermatitis probably exacerbated by allergic/hypersensitivity reactions to mite secretions/excretions that result in papulocrustous rashes with variable pruritus, scaling and dandruff (scurf) leading to dry dull unkempt dirty coats with a rusty granular appearance (colloquially called salt-and-pepper coats). Animal attempts at self-grooming often result in self-mutilation contributing to the development of papules, macules, crusts, excoriations, and alopecia (hairs easily epilated), particularly on the dorsal and lateral aspects of the hind limbs. Chronically infested animals may exhibit restlessness, fever, anorexia, and weight loss. Infested animals (especially cats) may also develop gingivitis, rectal irritation, and gastrointestinal disturbances with emesis (vomiting) of trichobezoars (hairballs) due to chronic over-grooming.

Developmental cycle and mode of transmission: Despite their occurrence as non-burrowing ectoparasites on the pelage of their hosts, the life-cycles of these fur mites remains poorly described. They undergo hemimetabolous (gradual or incomplete) metamorphosis where eggs hatch larvae that moult through nymphs to form adults. All stages may occur on the same individual host and transmission between hosts likely occurs by direct contact and possibly by contamination of fomites. Observations conducted on infested animals have revealed the presence of single eggs glued to host hair shafts as well as hexapod larvae, small octopod protonymphs, larger octopod deutonymphs and adult male and female mites attached firmly to hair shafts. Experimental studies have been conducted on mite developmental stages removed from hosts and cultured in humid chambers under laboratory conditions. They demonstrated that eggs hatched within 1-4 days, and that all motile stages (larvae, nymphs and adults) survived for 1-5 days. However, little is known about the duration of the developmental stages under natural conditions, nor the longevity and fecundity of adult mites. Epidemiological studies have suggested that infestations are not highly contagious and it has been proposed that most transmission may occur between hosts through direct contact, particularly when hosts come together socially for comfort, resting, sleeping, mating or nursing. Nonetheless, considering that motile stages may survive off hosts for short periods, some transmission may occur via contaminated fomites, probably through bedding in dens, burrows, nests and other resting places.

Differential diagnosis: While clinical infestations may be indicated on clinical grounds (scurfy pruritic mange), most signs are nonspecific and may be attributed to other causative agents, including other mites (trombiculids, *Notoedres*, *Otodectes, Cheyletiella*, *Sarcoptes*), lice (*Felicola*), fleas (*Pulex, Ctenocephalides*, *Echidnophaga*), miliary dermatitis (which includes food allergy dermatitis), eosinophilic granuloma complex, and some fungal infections. Diagnosis is conventionally made by the direct detection of mites in the pelage using magnifying glasses (or even an otoscope) or by the microscopic examination of hair plucks (trichograms), material collected by brushing fur or combing hair, or material adherent to transparent adhesive tape (skin scrapings are inappropriate). The fur mites can be readily identified by their distinct elongate shapes and their firm attachment to hairs. Mites and mite eggs ingested during grooming may also be occasionally detected in faecal samples following centrifugal floatation. Preliminary molecular biological studies have also been used to partially characterize mite samples by polymerase chain reaction (PCR) amplification of nuclear (18S ribosomal RNA) and mitochondrial (cytochrome oxidase I) gene sequences.

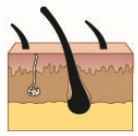
Treatment and control: Animals have been successfully treated using conventional topical acaricides (as shampoos, baths, sprays or powders) and more contemporary systemic acaricides (as spot-on, oral or injectable formulations); including lime sulphur, organochlorines (lindane), organophosphates (malathion), pyrethrin and synthetic pyrethroids (flumethrin), phenylpyrazoles (fipronil), neonicotinoids (imidacloprid), isoxazolines (afloxolaner) and macrocyclic lactones (selamectin, ivermectin, moxidectin, milbemycin). Many formulations are not strongly ovicidal, so repeated or protracted treatment is often required to combat newly-emergent stages and prevent re-infestation. Animals also seem to benefit from corticosteroid therapy to subdue allergic/hypersensitivity reactions. Even though infestations are not regarded as highly contagious, common-sense preventive measures should include animal isolation during treatment, the quarantine of new animals introduced to farms/households, good sanitation by the regular cleaning of cages, pens and bedding, and the exclusion of wildlife from animal holding areas. Early recommendations to use insecticides or acaricides with good residual activity as environmental sprays, mists or fogs to decontaminate animal facilities have largely gone out of favour since the introduction of long-lasting systemic formulations for resident animals.

Lynxacarus



Hosts
(mammals)

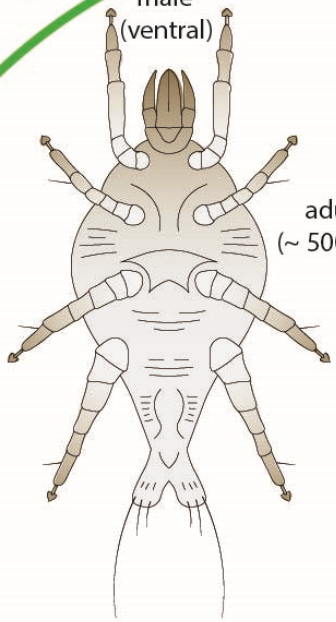
transmission between hosts by close contact
or via contaminated fomites



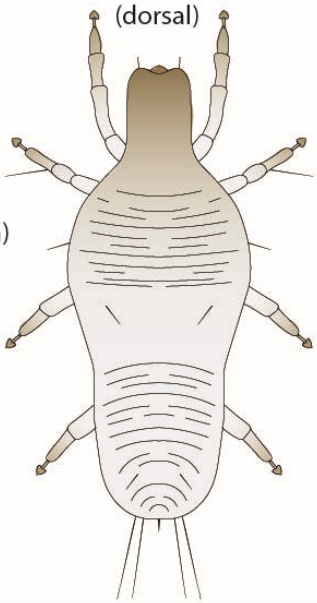
skin
(pruritus,
dermatitis,
unkempt
coats)

male
(ventral)

female
(dorsal)



adults
(~ 500 µm)

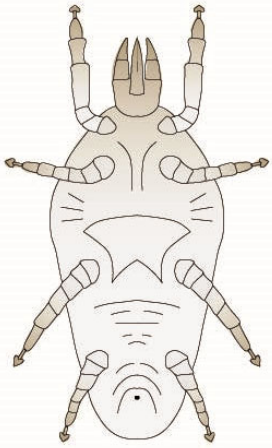


tarsal
elements

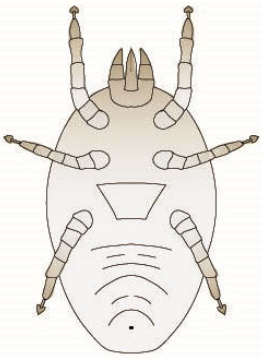
eggs attached
to pelage

egg
(~ 200 µm)

hatch



nymph
(ventral)
(~ 500 µm)



larva
(ventral)
(~ 300 µm)

2 nymphal instars
(proto-, deuto-nymphs)

all motile stages are ectoparasitic
(attach to hairs and feed on keratin/sebum)

Lynxacarus adult

Lynxacarus egg