Laminosioptes
(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). Laminosioptids are small mites with smooth elongated bodies bearing few setae. Infestations by *Laminosioptes* spp. cause subcutaneous nodules in birds, sometimes resulting in condemnation of poultry carcases.

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:	Acaroidea (stout body with transverse groove, small gnathosoma, chelicerae chelate)
Family:	Laminosioptidae (small mites, smooth elongated body, few setae, affect muscles of birds)
Genus:	*Laminosioptes* (parasitic in subcutaneous tissues of birds)
Species:	*L. cysticola* causes carcase condemnations in poultry

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).

The superfamily Acaroidea contains a large number of free-living mites that feed on mould and decomposing organic waste (some being notorious pests of stored foods such as grains, cheese, fruits, straw) as well as some nidicolous species inhabiting the nests of vertebrates (mammals and birds) and invertebrates (termites, beetles, bees, wasps, ants). They have small stout white-fawn bodies distinctly divided by transverse grooves into a proterosoma and hysterosoma, small heads (gnathosoma), chelate chelicerae, 4 pairs of legs conspicuously divided into 2 forward-facing pairs and 2 rear-facing pairs, and distinctive chaetotaxy (patterns of setae). Some 23 families have been recognized (Acaridae, Alloptidae, Analgidae, Apionacaridae, Avenzoariidae, Dermationidae, Dermoglyphidae, Epidermoptidae, Gaudoglyphidae, Knemidokoptidae, Kytoditidae, Laminosioptidae, Lardoglyphidae, Proctophyllodidae, Psoroptoididae, Pyroglyphidae, Sapracaridae, Saproglyphidae, Suidasiidae, Thysanocercidae, Trouessartiidae, Turbinoptidae, and Xolalgidae). The family Laminosioptidae comprises small quill/skin mites with smooth elongated bodies and few setae that infest birds, often affecting their muscles. The family is monotypic with a single genus *Laminosioptes* but with 5 species assigned to 4 subgenera: *L.* (*Laminosioptes*) (cheliceral movable digit with 3 tines, dorsum with 3 median and 2 paramedian plates); *L.* (*Psittaciella*) (cheliceral movable digit with 2 tines, dorsum with 4 median plates); *L.* (*Columbietta*) (cheliceral movable digit with single tine, dorsum with 5 median plates); and *L.* (*Passeriella*) (cheliceral movable digit with single tine, dorsum with 3 large median plates). These mites have elongated bodies with long setae, well-developed mouthparts, and four pairs of legs with claw-like tarsi on the first 2 pairs and long spatulate pretarsi on the posterior 2 pairs. One species (*L. L. cysticola*) invades the subcutaneous tissues of birds (mainly galliforms) and causes small flat oval nodules (hence their common name of fowl cyst mites).

***Laminosioptes* species**	**Hosts**	**Location**	**Clinical signs**	**Distribution**
Subgenus *L.* (*Laminosioptes*)				
L. (*L.*) *cysticola* (fowl cyst mite, subcutaneous mite)	Galliformes: phasianid (chicken, red-necked spurfowl, turkey); Columbiformes: columbid (pigeon)	subcutaneous tissues, lungs, peritoneum	carcase lesions, occasionally neurological lesions	worldwide
L. (*L.*) *hymenopterus*	Passeriformes: corvid (American crow)			North America
Subgenus *L.* (*Columbietta*)				
L. (*C.*) *collaris*	Columbiformes: columbid (plain-breasted ground dove)			Europe (zoo)
Subgenus *L.* (*Passeriella*)				
L. (*P.*) *reticulata*	Passeriformes: fringillid (Chinese grosbeak)			Europe (zoo)
Subgenus *L.* (*Psittaciella*)				
L. (*P.*) *myiopsittae*	Psittaciformes: psittacid (monk parakeet)			Europe (zoo)

Parasite morphology: Few details are available on the morphological characteristics of the various developmental stages of *Laminosioptes* spp. due to their cryptic and often encysted location within host tissues. Some information has been forthcoming from histological studies performed on tissue sections or by the microscopic study of stages recovered from skin scrapings. These mites are thought to produce 4 different types of stages during their development: eggs, larvae, nymphs and adults. Developing eggs have been observed *in utero* in female mites, and some species are thought to lay embryonated eggs while other species (e.g. *L. cysticola, L. collaris*) appear to be larviparous and give birth to fully-formed larvae. The larvae are oval-elliptical in shape measuring up to 140 μm long and they have 3 pairs of ventral legs without tarsal suckers. Nymphs are similar in shape but larger measuring up to 250 μm long and they have 4 pairs of ventral legs, the first pair having coxal epimeres joining to form a Y-shape. It is unclear how many nymphal stages are formed, although some reports suggest 2 instars occur (protonymphs and then deutonymphs). Adult mites have elongated oval-cylindrical bodies that are dorsoventrally flattened. They range considerably in size according to species, measuring from 240-860 μm in length. They have 2 main tagma: a small anterior gnathosoma (head) and a large posterior idiosoma (body). The gnathosoma is small (wider than long) and not visible in dorsal view. It bears small but well-developed mouthparts comprising a pair of 3-segmented chelicerae terminating in claw-like chelae (pincers) formed by fixed and movable digits (the latter with 1, 2 or 3 apical tines differentiating the subgenera *L.* (*Columbietta*) plus *L.* (*Passeriella*) from *L.*

(*Psittaciella*) and *L.* (*Laminosioptes*) respectively. The chelicerae are flanked by short sensory palps (without apoteles) and the mouth is directed ventrally with an unbarbed hypostome. It is thought the gut comprises a short foregut, an expanded midgut and a short hindgut terminating in a ventral anus. The idiosoma has 3-5 punctate dorsal plates depending on subgenus: *L.* (*Passeriella*) with 3 large median plates, *L.* (*Laminosioptes*) with 3 median and 2 paramedian plates, *L.* (*Psittaciella*) with 4 median plates, and *L.* (*Columbietta*) *w*ith 5 median plates. The rest of the cuticle is generally smooth although some species have transverse striations located between the dorsal plates. The body also bears a few long setae, including 2 caudal setate, but respiratory stigmata are absent. Adults have 4 pairs of well-developed ventral legs, 2 anterior pairs and 2 longer posterior pairs, all legs protruding beyond the body margin. The legs appear to have 5 short segments, with the basal coxae solidly fused to the body wall with pronounced thickened ridges (apodemes or epimeres). The apodemes of the first pair of legs join into a Y shape, and those on the posterior 2 pairs of legs appear to have lateral spurs. The first 2 pairs of legs terminate in claw-like tarsi with 1-2 pointed apical processes (not spines), while the posterior 2 pairs of legs end in long spatulate pretarsal stalks (pedicels without suckers). Adult mites display sexual dimorphism in size and structure, with males being smaller than females (240-400 cf. 250-860 μm) Male mites have 2 testes with tubular vas deferens leading to the long sheathed aedeagus (penis) opening to a ventral genital pore. Female mites have 2 ovaries with tubular oviducts leading to a globular uterus and an inverted Y-shaped vulva located ventrally between the coxae of the third pair of legs. Female mites may be oviparous (laying embryonated eggs) or larviparous (birthing live larvae).

Site of infection: These mites are obligate parasites of birds, although they behave more like endoparasites than ectoparasites. The mites invade subcutaneous tissues and reside in the fascia surrounding muscles, but may occur deeper in the lungs, peritoneum, and abdominal viscera. They often occur in clumps in the subcutis around the neck, breast, flanks and vent. A total of 5 species have been described from 2 passerine families (corvids, fringillids) and 3 non-passerine families (columbids, phasianids, psittacids).

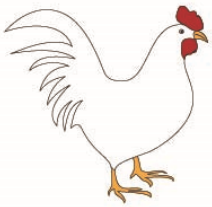
Pathogenesis: Infestations do not appear to cause acute clinical disease, but heavy and protracted infestations may result in nodule and cyst formation within internal tissues, leading to unsightly lesions and chronic disease manifestations. Mites penetrates into subcutaneous tissues where they feed on soft tissues (not blood). There is little or no inflammation associated with intact mites, and the only clinical signs at this stage seem to involve mild pruritus. Eventually the mites die in the tissues and become encysted in collagen forming white-cream flat oval nodules (hence the common name of cyst mite). Cysts are most frequently found in loose subcutaneous connective tissue, muscle fascia, abdominal viscera (kidneys, liver), peritoneum, lungs and air sacs. Degenerating mites and their fragments elicit mild to moderate granulomatous reactions and mineralization resulting in yellowish caseous and calcareous nodules up to several millimeters in diameter. Heavily infested birds may show lethargy, damaged plumage, feather loss, wasting, growth retardation, reduced egg production, and even death. Neurological signs have also been described in turkeys where mites infesting peripheral nerves caused incoordination, torticollis and drooping wings. Birds also appear to be highly susceptible to secondary bacterial infections. Nodular lesions in poultry reduce carcase quality and value and may result in condemnation upon meat inspection. Clinical manifestations in poultry occur more frequently in older, emaciated birds kept in unsanitary conditions, particularly in backyard and free-range conditions rather than intensive indoor poultry houses.

Developmental cycle and mode of transmission: The complete life-cycles of *Laminosioptes* spp. are not yet known, but like other acarines, they typically involve incomplete (hemimetabolous) metamorphosis where immature stages gradually transition through successive moults from larvae to nymphs to adults. All developmental stages have been observed on individual birds but their mode of transmission between birds is unclear due to their location and encystation beneath the skin. Adult mites live in nodules under the skin close to the surface of muscles where females produce live larvae or lay embryonated eggs. The larval stages are thought to feed on soft tissues before moulting to nymphs (possibly through 2 instars), which likewise feed before moulting to adult mites. It is not known whether any or all stages migrate to the skin surface or through the skin before forming their own nodules (like other astigmatid mites which create their own moulting burrows or pouches). It is therefore unclear as to which stages may be involved in the transmission of infestations between birds. Whilst all developmental stages have been found below the skin, mites have been collected from bird carcases washed and placed into bags, suggesting they may have transient surface-dwelling stages or mites may simply be leaving carcases as they cool. This has implications for their transmission, as most infestations have been associated with backyard or free-range operations where environmental contamination with off-host stages would be greatest. Further studies are required to determine the developmental cycle, longevity, fecundity and survival characteristics of these cryptic skin mites.

Differential diagnosis: Infestations are usually diagnosed at post-mortem by the detection of flat oval nodules containing mites in the subcutis or on muscles and visceral organs. Nodules may be observed visually when inspecting or dressing carcases and their contents examined more closely using a dissecting microscope. Infestations in poultry need to be differentiated from other causes of nodule formation, including subcutaneous nodules formed by acid-fast bacilli causing tuberculosis, and respiratory and visceral nodules caused by poultry air sac mites (*Cytodites*). Necropsy tissue samples may be collected for histological examination to reveal encysted mites or mite fragments. Mites have also been recovered from carcases washed in detergent and placed in bags. Alternatively, some infestations have been detected antemortem by the detection of mites in skin scrapings.

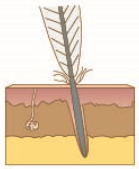
Treatment and control: Until recently, the most effective form of control has been to cull and destroy infested birds, and sometimes those in the immediate vicinity. While nodule/cyst formation is generally a chronic manifestation, chemotherapy with contemporary acaricides has been found to relatively effective, notably using systemic macrocyclic lactones (ivermectin). Protracted treatment may be required to reach invasive and encysted stages, and supportive therapy with antibiotics may be required to combat secondary bacterial infections. Several common-sense measures may also be adopted to reduce the risk of transmission, including the rapid removal and disposal of carcases, regularly cleaning cages, pens and runs, replacing litter and nesting materials, and routine health surveillance to monitor bird health and inform acaricidal treatments.

Laminosioptes



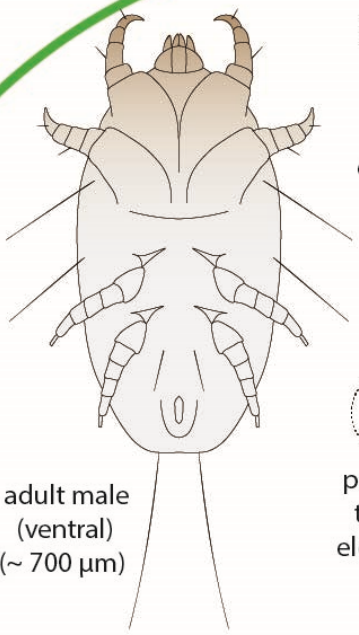
Hosts
(birds)

transmission between hosts by close contact
or via contaminated fomites



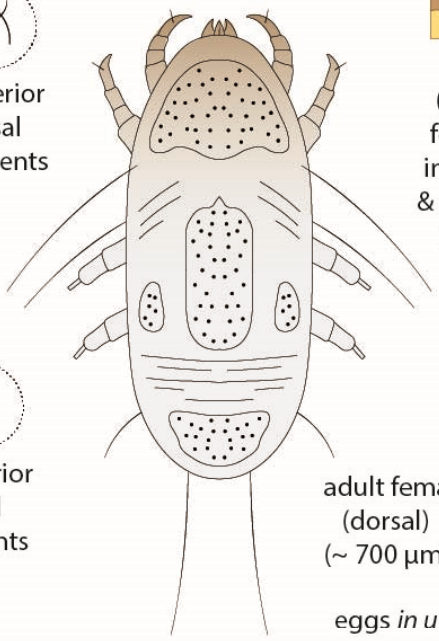
skin
(nodule
formation
in subcutis
& underlying
tissues)

anterior
tarsal
elements



adult male
(ventral)
(~ 700 µm)

posterior
tarsal
elements

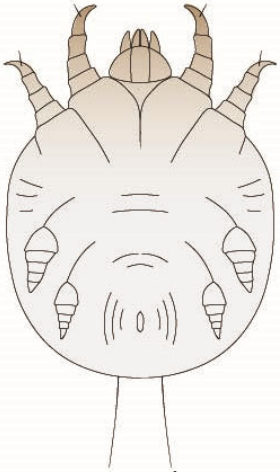


adult female
(dorsal)
(~ 700 µm)

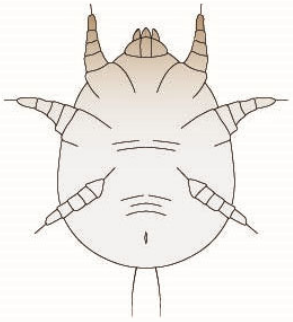
eggs *in utero*

adults burrow into skin and underlying tissues
(fibrotic nodules form around live, dying and dead mites)

egg
(~ 100 µm)



nymph
(ventral)
(~ 250 µm)



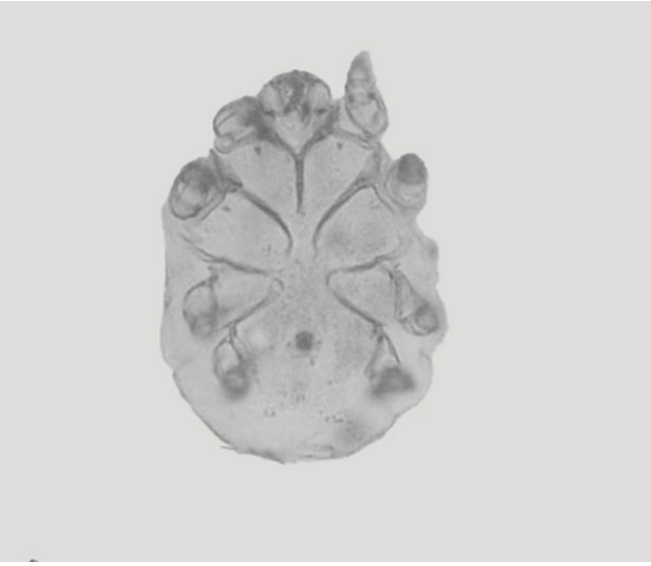
larva
(ventral)
(~ 140 µm)

2 nymphal instars
(proto-, deuto-nymphs)
excavate moulting pouches

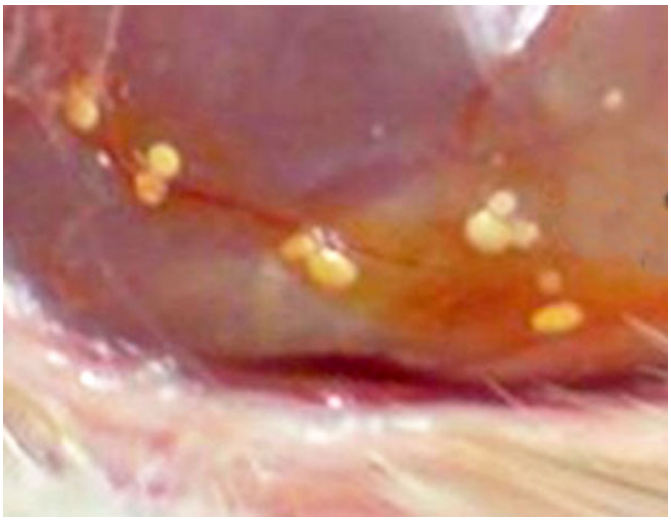
eggs/larvae
deposited in
subcutaneous
nodules

all motile stages are parasitic
(feed on soft tissues)

Laminosioptes adult



Laminosioptes adult



Laminosioptes cystic lesions