

Cytodites
(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). Cytoditid mites lack chelicerae and the palps are fused to form a sucking organ. They are parasites of the respiratory tracts of birds, rodents and bats. Infestations by *Cytodites nudus* in the air passages of poultry and canaries have been associated with respiratory disorders and emaciation.

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)
Family: Cytoditidae (respiratory parasites of birds, chelicerae absent, palps fused to form sucking organ)
Genus: *Cytodites* (parasitic in air sacs of birds)
Species: *C. nudus* causes airsacculitis in poultry and canaries

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 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	-
Raillietidae (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, Hemisarcoptioidea, Histiostomatoidea, Hypoderatoidea, Pterolichoidea, Sarcoptioidea) 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. Sarcoptioidea). 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. 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, Cytoditidae). The family Cytoditidae constitutes a unique group of small oval nude mites with reduced mouthparts (lacking chelicerae but with fused palps forming a sucking organ) that infect the respiratory passages of birds (hence their common names of nasal or airsac mites). The family is monotypic containing a single genus (*Cytodites*) with 10 species described from a range of bird species belonging to passerine and non-passerine families. In particular, one species (*C. nudus*) is problematic in poultry production by causing respiratory disease in chickens.

<i>Cytodites</i> species	Hosts	Location	Clinical signs	Distribution
<i>C. amandavae</i>	Passeriformes: estrilidid (red avadavat), ploceid (speckle-fronted weaver)			India, Africa
<i>C. arae</i>	Psittaciformes: psittacid (red-and-green macaw)			South America
<i>C. faini</i>	Passeriformes: laniid (red-backed shrike)			Europe
<i>C. geopeliae</i>	Columbiformes: columbid (bar-shouldered dove)			Australia
<i>C. hendrickxi</i>	Psittaciformes: psittacid (green-thighed parrot)			South America
<i>C. nudus</i> (syn. <i>Cytoleichus sarcoptoides</i> , <i>Cytodites glaber</i> , <i>Sarcoptes gerlachi</i>) (airsac mite)	Galliformes: phasianid (chicken, turkey, golden pheasant); Anseriformes: anatid (mallard); Columbiformes: columbid (pigeon); Coraciiformes: meropid (European bee-eater); Passeriformes: corvid (blue jay), fringillid (canary), leiotherichid (black-faced babbler)	air passages, lungs	excess mucus, coughing, respiratory difficulties, airsacculitis, loss of balance, emaciation	worldwide
<i>C. psittaci</i>	Psittaciformes: psittacid (Meyer’s parrot)			Africa
<i>C. psittaculae</i>	Psittaciformes: psittaculid (rose-ringed parakeet)			Africa
<i>C. therae</i>	Cuculiformes: cuculid (black-billed cuckoo)			North America
<i>C. tympanistriae</i>	Columbiformes: columbid (tambourine dove)			Africa

Parasite morphology: Like all mites, *Cytodites* spp. are thought to form 4 different types of morphological stages during their developmental cycles: namely, eggs, larvae, nymphs and adults. However, due to their inaccessibility in the respiratory tract, it has not been definitively established whether eggs hatch *in utero* or after oviposition, that is, whether these mites are viviparous or oviparous. Only motile developmental stages have been detected crawling over respiratory surfaces, with most reports indicating the occurrence of one larval and 2 nymphal instars. Larvae are small ovoid stages measuring around 150-200 µm long with 3 pairs of short stout legs (2 anterior pairs and one posterior pair). Nymphs are also ovoid but larger measuring 200-400 µm and having 4 pairs of stout legs (2 anterior pairs and 2 posterior pairs). The first nymphal instars (known as protonymphs) are around 230 µm in length and have irregularly striated cuticles and their legs terminate in short simple pretarsal ambulacra. The second nymphal instars (known as deutonymphs, although some earlier texts call them tritonymphs) are around 370 µm long and have fine but irregular cuticular striations, poorly developed setae (chaetotaxy) and legs ending in slightly longer ambulacra. Adult mites have oval slightly flattened bodies that are broader anteriorly and narrow posteriorly. They range considerably in size from 345-650 µm long by 230-500 µm wide. They have white chitinous cuticles often without striations, and very few fine setae which are often absent (adults are often referred to as ‘nude’ mites). They have 2 main tagma: a small anterior gnathosoma (head) and a large posterior idiosoma (body). The gnathosoma bears weakly-developed mouthparts where chelicerae are absent (or barely recognizable as minute highly-reduced pincer-like appendages) flanked by small smooth palps that are fused to form a soft sucking tube used to imbibe fluids. The alimentary tract comprises a tubular foregut (oesophagus, pharynx), saccular midgut (ventriculus with caeca), short tubular hindgut (with excretory Malpighian tubules) and subterminal ventral anus. The idiosoma lacks sclerotized shields and respiratory stigmata

and tracheae are absent (the mites breathe through their cuticles, like other Astigmata). The ventral idiosoma gives rise to 4 pairs of stout jointed legs, 2 pairs projecting forwards, 2 pairs projecting backwards and all extending well beyond the body margin. Each leg has 6 segments (coxa, trochanter, femur, genu, tibia, and tarsus) with the basal coxae fused to the body wall near thickened ridges (called epimeres or apodemes). The apodemes linked to the first pair of legs are characteristically fused distally to form a Y-shape. All legs end in short pretarsi with small rounded pulvilli (usually stalked in females, but not in males). Adult mites display sexual dimorphism with females being larger than males (450-650 cf. 450-550 μm). Male mites have 2 testes with vas deferens leading to the ejaculatory duct and long sheathed aedeagus (penis) opening to a ventral subterminal genital pore located near a V-shaped lobe. Female mites have 2 ovaries with oviducts leading to the uterus and vagina (with accessory organs (bursa copulatrix and spermathecae) for sperm reception and storage). Females have a longitudinal slit-like genital opening (gonopore) located around the ventral midbody.

Site of infection: *Cytodites* spp. occur in the respiratory systems of birds, with 10 species described in 13 families of birds belonging to 7 orders, including poultry, ducks, doves, cuckoos, parrots, bee-eaters and various passeriforms. While mites are conventionally considered to be ecto-parasites, these mites behave as endo-parasites as they commonly infest the air sacs, lungs and bronchial passages, although they are occasionally found in pneumatic bone cavities, the alimentary tract, peritoneum and body cavity.

Pathogenesis: Light infestations in birds may go unnoticed but heavier infestations may cause mild to severe respiratory disease. Birds have a pair of lungs and numerous thin-walled air sacs that extend into some bones thus reducing weight. They do not have diaphragms but rely on muscular contractions to respire. The presence of mites in the respiratory system feeding on host fluids may cause sufficient inflammation to compromise respiratory function, with granulomatous pneumonia and airsacculitis leading to excessive mucus, pulmonary oedema, creamy deposits, airway obstruction, dyspnoea, coughing, sneezing, gasping, clicking sounds, change in vocalization, wheezing and frequent swallowing. Infested birds become fluffed-up as they try to conserve body heat since the compromised respiratory system cannot maintain body temperature. Birds may exhibit frequent tail bobbing (due to the exertion of abdominal breathing), head shaking, beak rubbing, weakness, lethargy, weight loss, emaciation, incoordination, and death. Infiltrates of macrophages, eosinophils and plasma cells are often associated with histiocytic, lymphoplasmacytic, or granulomatous inflammation resulting in cloudy and thickened air sacs and firm red consolidations in the lungs with thick yellow pus in the bronchi. Infested birds are thought to be prone to secondary infections, including avian tuberculosis. In several cases, mites have been found outside the respiratory system, but their location in cavities or tubular organs may be the consequence of airsac rupture or penetration. These ectopic infestations have sometimes been tentatively associated with peritonitis, enteritis, and occasionally deaths in chickens.

Developmental cycle and mode of transmission: *Cytodites* spp. undergo gradual (hemimetabolous) metamorphosis involving eggs hatching larvae which moult through nymphs to form adults. All stages occur in the respiratory spaces of birds and the mode of transmission between birds remains speculative. It is not known whether gravid female mites lay eggs or retain them with the uterus until they hatch (some reports suggest they are oviparous, others viviparous). In either case, larval stages move about on respiratory surfaces feeding on host fluids using their small sucking mouthparts. The larvae moult through 2 nymphal instars before forming adult mites. All feeding stages appear as small white motile specks on the transparent host membranes. The life cycle appears to be completed in 14-21-days but little is known about the longevity or fecundity of the adults. It has been suggested that mites may undergo aerosol transmission between birds via respiratory secretions broadcast by coughing or sneezing, or by direct contact of bird nasal cavities during social behaviours (such as courtship, grooming or parents feeding their young). It is thought that the 'endo-parasitic' mites do not survive long outside of their hosts and they do not voluntarily leave hosts, even following host death. These speculations contra-indicate transmission via contaminated fomites, water or feed, but this remains to be demonstrated.

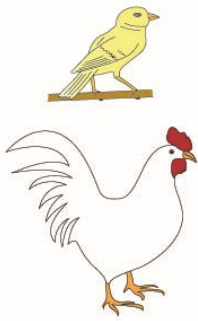
Differential diagnosis: Clinical infestations may be suspected on the basis of symptomatology, but other aetiological agents may cause similar respiratory signs, particularly bacterial or fungal pathogens but also including other mites (e.g. *Sternostoma*). Few ante-mortem diagnostic tests have proven effective, although the examination of oral/nasal swabs, tracheal trans-illumination and tracheal endoscopy may sometimes reveal the presence of mites. Radiography may reveal generalized nonspecific opacities in pulmonary and airsac fields. Most often, differential diagnosis can only be afforded by the post-mortem detection of mites in air sacs and bronchial passages and confirmed by their microscopic identification.

Treatment and control: Early studies reported some successes treating infestations using aerosol formulations of insecticidal dusts incorporating organophosphates (such as malathion), but now the most effective treatments involve the systemic application of macrocyclic lactones (ivermectin, moxidectin, selamectin). Repeated or prolonged treatment may be required, due to the partly privileged and protected site of infestation in the airways. In heavy infestations, the initial massive mortality of mites may cause respiratory symptoms to worsen temporarily prior to improving. Supportive therapy should also be provided using heat lamps to help birds maintain their body temperatures and antibiotics to combat bacterial infections. While intricacies of the transmission cycle have yet to be determined, common-sense preventive measures should be used to help contain infestations, including isolation

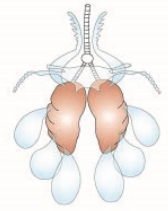
and quarantine procedures (sometimes culling infested birds), excluding wild birds from aviaries and poultry sheds, implementing strict hygiene and sanitation (cleaning cages/coops, replacing bedding/nesting materials), and even undertaking some environmental decontamination (spraying litter, cracks and crevices with long-lasting insecticides/acaricides).

Cytodites

transmission between hosts by close contact
or via aerosol contamination

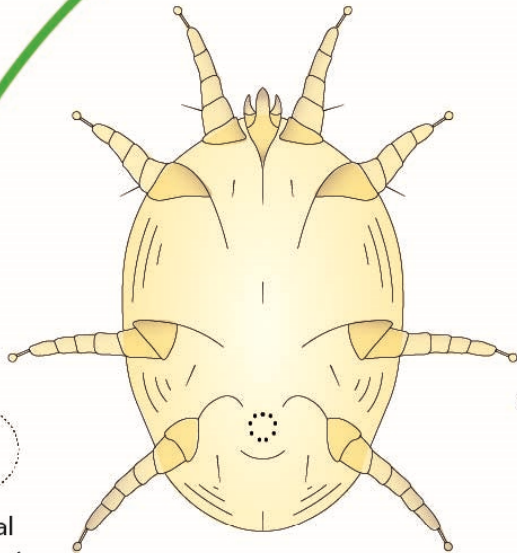


Hosts
(birds)

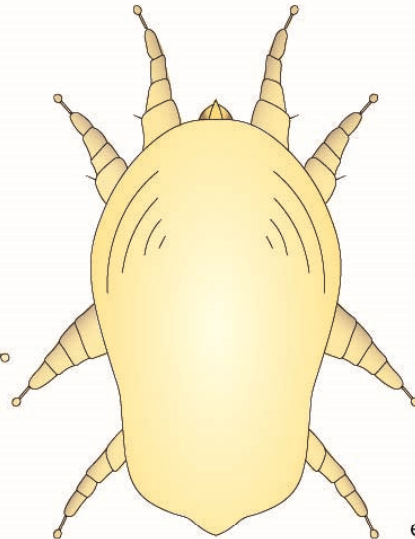


airways
(respiratory
disorders,
emaciation)

adult male
(ventral) (~ 500 μm)



adult female
(dorsal) (~ 500 μm)

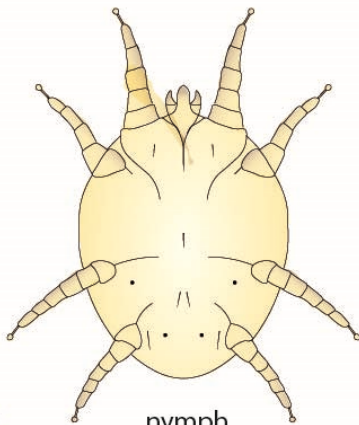


tarsal
elements

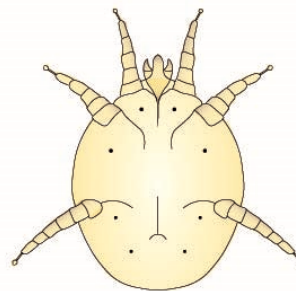
eggs *in utero*



egg
(~ 120 μm)



nymph
(ventral)
(~ 400 μm)

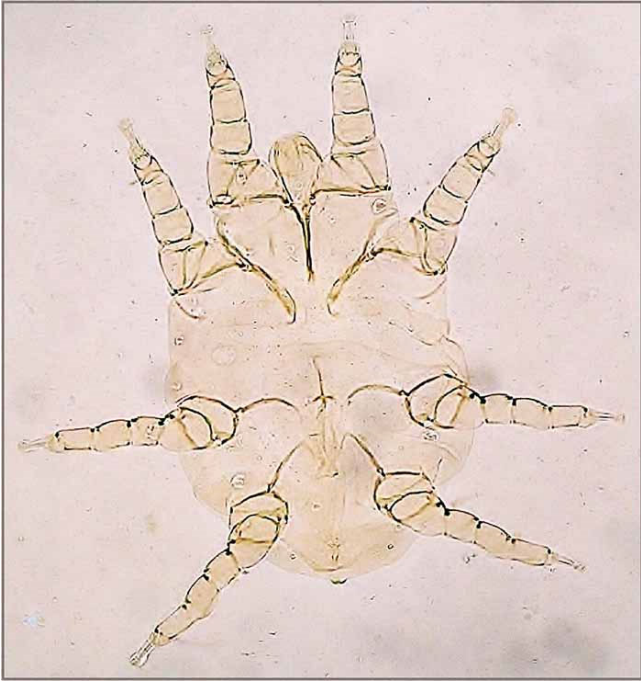


larva
(ventral)
(~ 200 μm)

hatch, larvae
deposited on
respiratory
surfaces

2 nymphal instars
(proto-, deuto-nymphs)

all motile stages are ectoparasitic
(feed on host fluids)



Cytodites adult