Knemidocoptes
(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). Knemidocoptids are burrowing scaly leg and face mites of birds with round bodies, no dorsal spines and short stubby legs. Infestations by *Knemidocoptes* spp. cause dermatitis characterized by feather depluming or scaly leg lesions in domestic poultry.

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:	Knemidocoptidae (burrowing scaly leg and face mites, round body, no dorsal spines, short stubby legs)
Genus:	*Knemidocoptes* (parasitic on skin of birds)
Species:	various species cause depluming itch or scaly leg in domestic 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	-
Knemidocoptidae (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, Knemidocoptidae, Kytoditidae, Laminosioptidae, Lardoglyphidae, Proctophyllodidae, Psoroptoididae, Pyroglyphidae, Sapracaridae, Saproglyphidae, Suidasiidae, Thysanocercidae, Trouessartiidae, Turbinoptidae, and Xolalgidae). The family Knemidocoptidae comprises burrowing mites with round bodies (lacking dorsal spines) and short stubby legs that invade the skin and/or feather shafts of birds. Six genera have been described (*Apocnemidocoptes*, *Evansacarus*, *Knemidocoptes*, *Micnemidocoptes*, *Neoknemidocoptes*, *Picicnemidocoptes*, *Procnemidocoptes*). Adult mites belonging to the genus *Knemidocoptes* (= *Knemidokoptes* = *Cnemidocoptes*) have rounded bodies with dorsal striations (broken or unbroken) forming simple or scale-like patterns, dorsal setae that are not spine-like, palps with 2 segments, legs without claws but with claw-like tarsi with terminal setae, posterior anus, and the female genital opening appears as a transverse slit paralleling body striations. Several species occur on domestic poultry and aviary birds in association with clinical disease. Leg and face mites cause local dermatitis (conditions known as scaly leg and scaly face), while feather mites may cause significant feather loss (depluming itch).

Parasite species	Hosts	Location	Clinical signs	Distribution
Knemidocoptes				
K. derooi	Apodiformes: apodid (African palm swift)	legs		Africa
K. fossor	Passeriformes: estrilidid (white-headed munia), fringillid (common chaffinch)			Asia
K. glaberrimus	Piciformes: picid (middle spotted woodpecker)			Europe
K. intermedius	Passeriformes: prunellid (rufous-breasted accentor), corvid (common raven, forest raven), artamid (pied currawong), menurid (superb lyrebird)	legs	scaly leg	Eurasia
K. jamaicensis	Passeriformes: alaudid (Eurasian skylark), corvid (common crow, American crow, rook), drepanid (Hawaii amakihi), emberizid (greater Antillean bullfinch, eastern towhee), estrilid (Gouldian finch), fringillid (canary, common chaffinch, European goldfinch, common linnet, common redpoll, twite, Eurasian siskin, brambling, red crossbill, Eurasian bullfinch, evening grosbeak), icterid (red-winged blackbird, Brewer's blackbird, brown-headed cowbird, common grackle), motacillid (pipit, Cape wagtail), mimid (gray catbird, northern mockingbird), parulid (prairie warbler, palm warbler, Cape May warbler, green-tailed warbler), parid (great tit, Eurasian blue tit, black-capped chickadee), passerellid (rufous-sided towhee), phaenicophilid (black-crowned palm tanager), sittid (white-breasted nuthatch), sturnid (common mynah), sylviid (sedge warbler), turdid (white-chinned thrush, golden thrush, spectacled thrush, American robin), tyrannid (Hispaniolan pewee, great crested flycatcher); Piciformes: picid (woodpecker),	legs	scaly leg	cosmopolitan
K. laevis (depluming mite)	Passeriformes: fringillid (common chaffinch), passerid (house sparrow); Columbiformes: columbid (pigeon)	skin (feather shafts)		Europe

K. mutans (scaly leg mite)	Galliformes: phasianid (chicken, turkey, pheasant, partridge); Anseriformes: anatid (Cape Barren goose); Strigiformes: strigid (great horned owl)	skin (esp. feet, legs)	raised leg scales, lameness, malformation, emaciation	worldwide
K. philomelae	Passeriformes: muscicapid (thrush nightingale)			Europe
K. pilae	Psittaciformes: psittaculid (budgerigar, yellow-crowned parakeet, Alexandrine parakeet, ring-necked parakeets, scarlet-chested parrot, Princess parrot, yellow-fronted kakariki), psittacid (Amazon parrot, red-and-green macaw), cacatuid (sulphur-crested cockatoo, palm cockatoo, cockatiel); Passeriformes: fringillid (canary, European goldfinch)	skin (esp. beak, mouth, cere)	scaly face, white proliferative encrustations, warty lesions, ribbon-like skin proliferations (tassel foot), overgrowth of toenails, affect ability to perch	cosmopolitan
Neoknemidocoptes				
N. australiensis	Passeriformes: estrilidid (zebra finch)			Australia
N. columbicola	Columbiformes: columbid (pigeons)	skin (feathered areas)	pruritus, dermatitis	Eurasia
N. columbigallinae	Columbiformes: columbid (pigeon, croaking ground dove)	skin (feathered areas)	pruritus, dermatitis	South America
N. gallinae (syn. *Knemidokoptes*) (depluming itch mite)	Galliformes: phasianid (chicken, turkey, pheasant, partridge); Anseriformes: anatid (goose); Columbiformes: columbid (pigeon)	skin (feather shafts)	depluming itch, scales, papules, thickened skin	worldwide
N. philetairus	Passeriformes: ploceid (sociable weaver)			Africa

Parasite morphology: These bird mites produce 3 different types of morphological developmental stages: larvae, nymphs (2 instars) and adult mites (male and female). Females are ovoviviparous and give birth to larvae rather than laying eggs. The larvae have oval-round bodies measuring 200-300 µm in length and they have 3 pairs of short stubby legs, all terminating in stalked pulvilli. Two nymphal stages have been described: protonymphs followed by deutonymphs (sometimes called tritonymphs). They have rounded bodies measuring from 250-400 µm in length and they have 4 pairs of legs without pulvilli. Nymphs generally appear as smaller versions of adults but they lack genitalia. Adult mites have round-globose bodies ranging in size from 200-500 µm depending on species. They have 2 main tagma: a small anterior gnathosoma (head) and large posterior idiosoma (body). The gnathosoma is short (wider than long) and bears small mouthparts consisting of a pair of short 3-segmented chelicerae flanked by small 2-segmented palps. The mouth is directed ventrally and has a dorsal rostrum and an unbarbed hypostome. The alimentary tract appears to consist of a short tubular foregut (oesophagus, pharynx), saccular midgut (ventriculus with caeca), and a short hindgut (with excretory Malpighian tubules) opening through a terminal dorsal anus. The dorsal surface of the idiosoma is covered with fine cuticular striations that are broken mid-dorsally in a plate- or scale-like pattern (in *Knemidocoptes* spp.) or simple and unbroken, sometimes distally denticulate (in *Neoknemidocoptes* spp.). Adult mites have a distinctive anterior dorsal shield marked by a pair of longitudinal medial apodemes running to the base of mouthparts, and male mites also have a median posterior dorsal shield. The idiosoma also contains several dorsal setae that are not spine-like or triangular, and a pair of long caudal setae. Like other Astigmata, mites do not have respiratory stigmata but they breathe through their cuticles. The ventral idiosoma possesses 4 pairs of short stubby legs (longer in males than females), with 2 larger anterior pairs projecting forwards beyond the body margin, and 2 small posterior pairs projecting backwards but not beyond the body margin. The legs have 6 small segments (coxa, trochanter, femur, genu, tibia, and tarsus) with all coxae fused to the body wall. The first 2 pairs of legs have cuticular thickenings (apodemes or epimeres) that are widely separated, but join on males to form a midventral Y shape. The apodemes on the 2 posterior pairs of legs are long but not joined. All the legs on female mites end in short setae (suckers are absent), while all the legs on male mites have long setae and small cup-shaped suckers (pulvilli) on long stalks. Adult mites display additional sexual dimorphism, with males being smaller than females (200-250 x 145-160 cf. 340-500 x 280-380 µm). Males have 2 testes with tubular vas deferens leading to an ejaculatory duct and long sheathed aedeagus (penis) opening to a subterminal ventral genital pore. Female mites have 2 ovaries with tubular oviducts leading to a globular uterus and vulva which opens to a transverse slit-like genital pore.

Site of infection: These astigmatid mites are obligate ectoparasites that burrow into the superficial layers of the skin of birds. Most mite species exhibit high host specificity and tissue tropism, infesting particular bird species at different anatomical sites. Some 9 *Knemidocoptes* spp. have been described from 23 passerine families (alaudids, artamids, corvids, drepanids, emberizids, estrilids, fringillids, icterids, menurids, motacillids, mimids, muscicapids, parulids, parids, passerids, passerellids, phaenicophilids, prunellids, sittids, sturnids, sylviids, turdids, and tyrannids); and another 9 non-passerine families (anatids, apodids, columbids, phasianids, picids, psittaculids, psittacids, cacatuids, and strigids). Many species infest bare or lightly-feathered areas, especially around the beak, while others infest the lower legs, feet, and occasionally the combs and wattle. Another 5 *Neoknemidocoptes* spp. have been described from 2 passerine families (estrilidids, ploceids) and another 3 non-passerine families (anatids, columbids and phasianids, including domestic poultry). Mites generally infest the bases of feather shafts on the back, head, neck, wing and around the vent.

Pathogenesis: Many infestations remain subclinical, but some may cause severe deforming diseases, particularly when birds are stressed, immuno-compromised or otherwise genetically susceptible. Different mite species cause different diseases in birds which can be life-threatening by affecting their ability to perch, preen or feed. Mites burrow into the stratum corneum of the skin forming tunnels in which they live, feeding on skin cells and fluids. Infestations may cause 3 different types of knemidocoptic mange depending on which mite species are involved and which part of the body is attacked. Some species infest non-feathered areas on the legs and feet causing a scaly mange condition known as scaly leg, some species infest lightly-feathered areas around the beak causing scaly face, and some infest feathered areas over the body causing feather loss known as depluming itch. These conditions are not completely independent of each other, as several species may infest multiple sites causing 2 or more conditions (e.g. *K. mutans* and *K. pilae* may infest both the legs and faces of psittacine and galliform birds). Mites on the legs are found under skin scales where they cause local inflammation (dermatitis) with hyperplasia and hyperkeratosis resulting in white scaly encrustations (known as scaly leg). Sometimes, ribbon-like skin proliferations are observed (condition known as tassel foot in canaries and finches, often accompanied by overgrowth of the toenails affecting the ability of birds to perch). Persistent infestations lead to nodular thickening of the skin, elevation of the leg scales, lameness and deformity of feet, legs and claws, sometimes loss of digits. Birds become highly stressed, indulge in intensive self-grooming, stop feeding and waste away. Infestations in poultry sheds can lead to significant losses in production. Mites on the face also cause local dermatitis with hyperkeratosis leading to white proliferative encrustations (known as scaly face), particularly on the beak, cere (fleshy tissue above the beak), around the corners of the mouth and sometimes around the eyes. Infestations cause significant irritation and stress to birds and may affect their ability to feed and preen leading to emaciation and death. Mites infesting feathered areas of the body burrow into the bases of feather shafts, particularly on the back, head, neck, wings and around the vent. They cause inflammation with intense pruritus and the skin may become thickened, papular, scaly and wrinkled. The feathers break easily and are often pulled out by the bird when preening resulting in significant feather loss (depluming) with bare patches on the back which may spread to the wings, neck and head. Infestations by knemidocoptic mange mites are more common in birds with ground access and more prevalent in barn-yard and deep-litter farming systems than in caged production facilities.

Developmental cycle and mode of transmission: Knemidocoptic mites undergo incomplete (hemimetabolous) metamorphosis involving a gradual transition in body plan via successive moults from larvae to nymphs to adults. These mites are unusual, however, in that females are ovoviviparous rather than oviparous and give birth to larvae rather than laying eggs. All life-cycle stages may occur on the same individual host, and transmission between hosts occurs by contact with infested birds or infested fomites. Adult mites live in burrows or tunnels in the superficial layers of the skin. Gravid females produce larvae in these tunnels which subsequently crawl to the skin surface, and then excavate their own shallow burrows (or moulting pockets) in the skin. After several days, the larvae moult to form first-stage nymphs (protonymphs), most of which emerge and form their own moulting pouches where they moult to second-stage nymphs (deutonymphs, sometimes called tritonymphs) after several days. The deutonymphs may remain in these burrows or emerge to dig their own moulting pouches. After several days, they undergo their final moult to adult mites. Male mites emerge and seek females either on the skin surface or in moulting burrows. After fertilization, females expand their moulting pouches or create new tunnels and begin producing larvae one at a time. Little is known about the longevity or fecundity of the mites, but their whole life-cycle may be completed in 17-21 days. Infestations are regarded to be highly contagious and most transmission is thought to occur by close and prolonged contact between birds (sometimes involving only one species in a mixed aviary). There have been some reports of mites being transmitted to unfeathered offspring in nests, and studies have shown that mites may survive for up to 4-9 days off hosts. This means that some transmission probably occurs via fomites (cages, nests, boxes, perches, litter, soil) contaminated with mites dislodged from hosts.

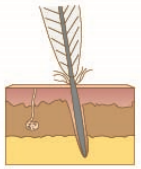
Differential diagnosis: Clinical infestations cause relatively specific clinical signs (scaly face, scaly leg, depluming itch) which can be used to facilitate provisional diagnosis. Diagnoses are confirmed by the direct detection and microscopic identification of mites in clinical samples, notably skin scrapings taken from affected areas, including the bases of feathers. Mites are generally found in burrows at the edges of skin lesions and amongst skin scales and crusts. Skin samples are best subjected to caustic digestion in potassium hydroxide solutions to break down host material leaving the mites untouched (their cuticles are impervious to digestion). Mites may also be detected in histological sections prepared from antemortem skin biopsies or post-mortem skin samples. More recently, molecular biological techniques have been used to detect and characterize mite species by polymerase chain reaction (PCR) amplification of nuclear (18S ribosomal DNA) and mitochondrial (cytochrome c oxidase subunit I) gene sequences.

Treatment and control: Birds have been successfully treated for scaly mange using a variety of conventional topical acaricides (dusts, sprays, showers, baths) and more contemporary systemic formulations (oral, injectable, spot-ons), including sulphur baths, mineral oil, carbamates (carbaryl), anilides (crotamiton), organochlorines (lindane), organophosphates (coumaphos, malathion) and macrocyclic lactones (ivermectin, selamectin, moxidectin). Repeated or prolonged treatments are often required, as the mites are somewhat protected by their cryptic locations in skin burrows. Careful attention should also be paid to any drug contra-indications as some chemicals are toxic to birds and may cause adverse reactions. Animals should also be given supportive therapies during treatment, particularly with antiseptics and antibiotics to combat secondary bacterial infections, especially when open lesions are present. A range of preventive measures have been used to control infestations, including regular health surveillance (careful monitoring to facilitate timely treatment, isolation and quarantine), good sanitary practices (cleaning and disinfection of aviaries, cages, food and water dispensers, regularly changing litter and nesting materials, treating porous fomites with residual acaricides) and securing animal holding facilities (excluding wildlife and vermin using barriers, traps or baits).

Knemidocoptes

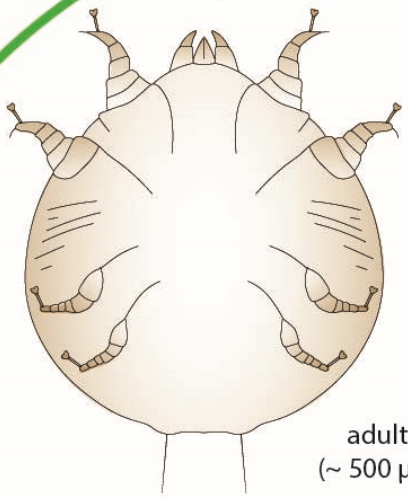
Hosts
(birds)

transmission between hosts by close contact
or via contaminated fomites



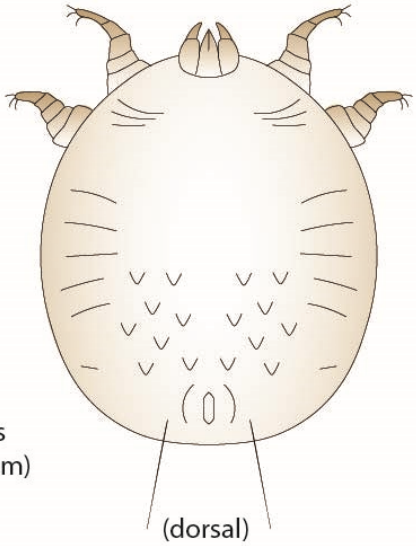
skin
(dermatitis,
feather
depluming,
scaly leg
lesions)

male



(ventral)

female



(dorsal)

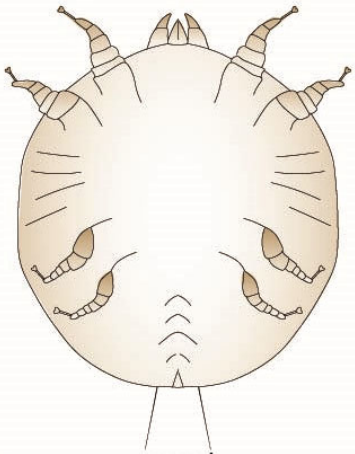
adults
(~ 500 µm)

tarsal
elements

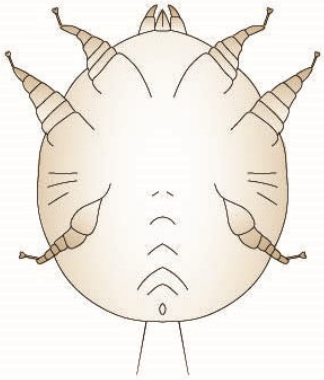
eggs *in utero*

egg
(~ 200 µm)

adults burrow into skin forming tunnels



nymph
(ventral)
(~ 400 µm)

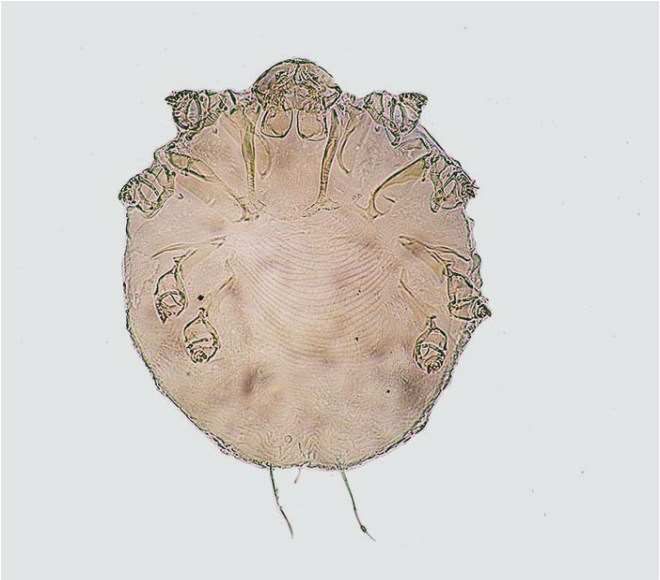


larva
(ventral)
(~ 300 µm)

larvae
deposited in
tunnels in skin

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

all motile stages are ectoparasitic
(burrow and feed on skin cells and fluids)



Knemidocoptes adult

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