Dermanyssus
(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 (capitulum). 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. Gamesid mites have anterior legs with respiratory stigmata located between the second and fourth legs. Most species are predatory, but some are ectoparasitic on mammals, birds and insects. They usually have a large sclerotized dorsal shield and a series of smaller ventral shields. Dermanyssid mites are large blood-feeding ectoparasites with greyish-white bodies becoming red when engorged. Infestations by *Dermanyssus* spp. may cause irritation and anaemia in domestic poultry, and mites may also bite mammals (including humans) in proximity to infested sheds.

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:	Parasitiformes (ticks and some mites, with posterior stigmata)
Order:	Mesostigmata (gamesid mites, legs grouped anteriorly, stigmata between second and fourth legs)
Suborder:	Dermanyssina (sclerotized shields, reduced setae, legs with claws)
Superfamily:	Dermanyssoidea (elongate edentate chelicerae, diverse life-styles)
Family:	Dermanyssidae (blood-feeding ectoparasites, greyish-white bodies becoming red when engorged)
Genus:	*Dermanyssus* (parasitic on skin/feathers of mammals/birds)
Species:	various species cause irritation and anaemia 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 Parasitiformes comprises acarines with posterior respiratory stigmata and includes two major orders: the ixodid ticks (order Metastigmata) with stigmata located posterior to the legs; and the gamesid mites (order Mesostigmata) where they are located between the legs, sometimes associated with sinuous processes (peritremes). Mesostigmatid mites are further characterized by possessing unbarbed hypostomes, and long legs with free coxae (not fused to the body wall). The order Mesostigmata contains thousands of mites, with over 5,000 species recognized in 660 genera and 100 families. Nine suborders are recognized (Antennophoria, Arctacarina, Cercomegistina, Dermanyssina, Epicriina, Microgyniina, Parasitina, Sejina, and Uropodina). The suborder Dermanyssina contains robust mites with distinct sclerotized dorsal and ventral shields, reduced setae, palps with 2-tined apoteles, and legs with tarsal claws. Five superfamilies are recognized (Ascoidea, Dermanyssoidea, Eviphidoidea, Rhodacaroidea, and Veigaioidea). The superfamily Dermanyssoidea contains a diverse array of mites including free-living predators, nidicoles in the nests of vertebrates and insects, obligate and facultative ectoparasites of vertebrates and arthropods, and even respiratory and auditory endoparasites of mammals, birds, and some reptiles. The mites have elongated chelicerae (long first or second segment) with small edentate digits and concave interior margins (functioning as a tube when in opposition). A total of 11

families are recognized (Dermanyssidae, Haemogamasidae, Halarachnidae, Hirstionyssidae, Ixodorhynchidae, Laelapidae, Macronyssidae, Raillietiidae, Rhinonyssidae, Spinturnicidae, and Varroidae), many of them exclusively parasitic.

The family Dermanyssidae contains haematophagous mites that are ectoparasitic primarily on birds, although several species infest mammals. Mites are often nidicolous living in nesting materials and intermittently infesting hosts for blood meals. Dermanyssids have ovoid bodies (idiosoma) that are rounded posteriorly and they have elongated extrusible chelicerae with long second segments. Many species also exhibit neopodospermy (sperm transfer through accessory insemination pores located closer to legs) where the male chelicerae are broader and modified as gonopodes possessing enlarged chelae with long spermatodactyls (movable digits used for sperm transfer). Four genera are recognized on birds and rodents (*Dermanyssus, Draconyssus, Laelaspisella, Liponyssoides*). The genus *Dermanyssus* is characterized by adult mites with long dorsal shields, narrow sternal shields bearing 1-2 pairs of setae, well-defined genital shields (like *Ornithonyssus*), elongate anal shields (more oval in *Ornithonyssus*), and long whip-like chelicerae (not short and stout like *Ornithonyssus*) with tiny terminal chelae. Some 26 species are recognized mostly on avian hosts although many may opportunistically feed on mammals. Several species (especially *D. gallinae*) have been associated with significant economic losses on poultry farms due to lowered meat and egg production, as well as acting as vectors for the transmission of several viral and bacterial diseases.

***Dermanyssus* species**	**Hosts**	**Clinical signs**	**Distribution**
D. alaudae (syn. *D. truncatus*)	Passeriformes: alaudid (Eurasian skylark, woodlark)		Eurasia
D. americanus (syn. *D. oti*) (American bird mite)	Passeriformes: emberizid (meadow bunting), fringillid (canary, house finch), passerid (house sparrow, Eurasian tree sparrow), sittid (nuthatch); Accipitriformes: accipitrid (sharp-shinned hawk); Strigiformes: strigid (eastern screech owl, northern saw-whet owl, long-eared owl); Chiroptera: vespertilionid (canyon bat); Primates: hominid (human)	trauma, irritation	Americas
D. antillarum	Passeriformes: mimid (northern mockingbird), passerid (house sparrow); Accipitriformes: accipitrid (sharp-shinned hawk); Apodiformes: apodid (Antillean palm swift)		North America
D. apodis	Apodiformes: apodid (common swift, pallid swift)		Europe
D. brevirivulus	Passeriformes: alaudid (crested lark)		Eurasia
D. brevis	Passeriformes: alaudid (Eurasian skylark, horned lark)		Eurasia
D. carpathicus	Passeriformes: muscicapid (common redstart), parid (great tit)		Eurasia
D. chelidonis	Passeriformes: fringillid (European goldfinch), hirundinid (sand martin, common house martin, barn swallow, Eurasian crag martin), parid (Eurasian blue tit)		Eurasia, Africa, Americas
D. faralloni	Procellariiformes: hydrobatid (ashy storm petrel); Charadriiformes: alcid (pigeon guillemot, Cassin's auklet)		North America
D. gallinae (syn. *D avium, evotomydis, hominis*) (chicken mite, poultry mite, red mite, roost mite)	Galliformes: phasianid (chicken); Passeriformes: acrocephalid (great reed warbler), emberizid (yellowhammer), fringillid (canary, European goldfinch, Eurasian siskin), hirundinid (common house martin, sand martin, barn swallow), muscicapid (European robin, collared flycatcher, European pied flycatcher, common redstart), parid (great tit, coal tit), passerid (house sparrow, Eurasian tree sparrow), remizid (Eurasian penduline tit), sittid (Eurasian nuthatch), sturnid (common starling); Piciformes: picid (Eurasian wryneck); Columbiformes: columbid (pigeon, rock dove); Coraciiformes: meropid (European bee-eater); Psittaciformes: psittaculid (lovebird); Accipitriformes: accipitrid (white-backed vulture); Falconiformes: falconid (saker); Strigiformes: strigid (boreal owl); Rodentia: cricetid (northern grasshopper mouse, canyon mouse, southern red-backed vole, desert wood rat), murid (black rat); Lagomorpha: leporid (marsh rabbit); Carnivora: canid (dog), felid (cat); Perissodactyla: equid (horse); Chiroptera: vespertilionid (cave myotis, tricolored bat); Primates: hominid (human)	trauma, irritation, erythema, pruritus, anaemia (plus vectors for avian spirochaetosis)	worldwide
D. gallinoides	Piciformes: picid (pileated woodpecker, Lewis's woodpecker, downy woodpecker, red-shafted flicker, yellow-bellied sapsucker)		North America
D. grochovskae	Passeriformes: corvid (spotted nutcracker); Piciformes: picid (white-backed woodpecker, great spotted woodpecker, Japanese green woodpecker)		Palearctic

D. hirsutus (syn. *D. scutatus*)	Piciformes: picid (northern flicker)		North America
D. hirundinis	Accipitriformes: accipitrid (lesser spotted eagle); Anseriformes: anatid (tufted duck, common pochard, greylag goose); Apodiformes: apodid (little swift, chimney swift); Columbiformes: columbid (rock dove); Coraciiformes: meropid (European bee-eater); Passeriformes: acrocephalid (great reed warbler, marsh warbler, Eurasian reed warbler), estrilidid (zebra finch), hirundinid (common house martin, sand martin, barn swallow, tree swallow, cliff swallow), laniid (lesser grey shrike, red-backed shrike), motacillid (tree pipit), muscicapid (collared flycatcher, common nightingale, black redstart), parid (Eurasian blue tit, great tit, marsh tit), passerid (house sparrow, Eurasian tree sparrow), remizid (Eurasian penduline tit), sittid (Eurasian nuthatch), sturnid (common starling), troglodytid (house wren, Eurasian wren), turdid (ring ouzel), vireonid (red-eyed vireo); Piciformes: picid (downy woodpecker); Strigiformes: strigid (tawny owl, long-eared owl); Primates: hominid (human)	trauma, irritation	North America
D. longipes	Passeriformes: passerid (house sparrow)		Europe
D. nipponensis	Piciformes: picid (Japanese green woodpecker)		Japan
D. passerinus	Passeriformes: emberizid (yellowhammer), muscicapid (collared flycatcher), parid (great tit), passerid (Italian sparrow), sturnid (common starling); Piciformes: picid (Eurasian wryneck)		Eurasia
D. prognephilus	Passeriformes: hirundinid (purple martin), icterid (brown-headed cowbird), muscicapid (eastern bluebird); Piciformes: picid (red-shafted flicker, downy woodpecker, red-headed woodpecker)		North America
D. quintus	Piciformes: picid (great spotted woodpecker, downy woodpecker, white-backed woodpecker, Eurasian three-toed woodpecker, European green woodpecker)		Eurasia
D. richiardii	Hymenoptera: apid (carpenter bee); Lepidoptera: cossid (goat moth)		Europe
D. rwandae	Apodiformes: apodid (little swift)		Europe
D. transvaalensis	Passeriformes: hirundinid (South African cliff swallow)		Africa
D. triscutatus	Passeriformes: hirundinid (cliff swallow)		Americas
D. trochilinis	Apodiformes: trochilid (hummingbird)		Americas
D. wutaiensis	Passeriformes: passerid (Eurasian tree sparrow)		Eurasia

A small range of other *Dermanyssus* spp. originally described from other vertebrate hosts have subsequently been re-assigned to other genera; including: *D. musculi, murinus = Steatonyssus; D. arcuatus, albatus, carnifex, coriaceus, lanius, noctulae, pipistrellae = Echinonyssus; D. natricis = Ophionyssus; D. flavus, glutinosus, granulosus = Macronyssus; D. ambulans = Haemogamasus; D. aegypticus, brasiliensis, intermedius, muris, sanguineus = Liponyssoides;* and *D. lacertarum = Neoliponyssus.*

Parasite morphology: Like all mites, *Dermanyssus* spp. form 4 different types of morphological stages during their development: namely, eggs, larvae (one instar), nymphs (2 instars) and adults (males and females). Eggs are small pearly-white ovoid stages measuring around 0.4 mm in length. Larvae are small white-tan stages measuring 0.4-0.6 mm in length. The have a small anterior gnathosoma (head or capitulum) earing small mouthparts and a larger ovate-discoidal idiosoma (body) with 3 pairs of long jointed legs arising from the anteroventral surface. Nymphs are larger in size and have 4 pairs of long legs and their mouthparts have long thin chelicerae with elongate second segments. Two nymphal instars are formed, the first (protonymphs) having tan ovate bodies measuring 0.5-0.8 mm long, and the second (deutonymphs) having reddish-brown ellipsoidal bodies measuring 0.7-1.0 mm long. Adult mites have robust ovoid bodies measuring 0.7-1.5 mm in length. They range from cream to grey in colour but become reddish-brown when engorged on host blood. Morphometric studies have indicated that most *Dermanyssus* spp. may be allocated to 2 species groups: the *gallinae*-group containing species with soft expandable bodies and thin legs (*D. antillarum, D. carpathicus, D. chelidonis, D. faralloni, D. gallinae, D. gallinoides, D. hirundinis, D. longipes, D. nipponensis, D. prognephilus, D. transvaalensis, D. triscutatus, D. trochilinis,* and *D. wutaiensis*); and the *hirsutus*-group comprising species with compact bodies and thicker legs (*D. alaudae, D. americanus, D. brevirivulus, D. brevis, D. grochovskae, D. hirsutus, D. passerines, D. quintus* and *D. rwandae*). The anterior gnathosoma bears long mouthparts (chelicerae, hypostome) flanked by long sensory palps. Like other mesostigmatid mites, the palps have 5 segments (whereas those of prostigmatid and astigmatid mites have 1-2 segments) and they terminate in 2-tined claws (apoteles). The basal segments of the palps are also fused to form a basis capitulum supporting the chelicerae and hypostome. The stylet-like chelicerae are extrusible and form a long piercing structure when fully extended for feeding, but are kept retracted when not in use. They have 3 long thin segments, with the second segment being the longest (whereas the first segment is longest in macronyssids). The chelicerae terminate in small chelae (pincers) with edentate digits (one fixed, one movable) and

medially concave faces that form a tube when in opposition. The mouth has a dorsal rostrum, ventral buccal cone and an unbarbed hypostome (barbed in ticks). The alimentary tract comprises the mouth (with paired salivary glands), foregut (with tubular oesophagus and pharynx), midgut (saccular ventriculus with gastric caeca, and short tubular intestine), hindgut (with excretory Malpighian tubules, tubular rectum, and subterminal anus). The idiosoma bears numerous long setae and has distinct sclerotized dorsal and ventral (sternal, genitoventral, and anal) shields. The dorsal shield is trapezoidal with tapering sides and a truncated posterior margin (while that of *Ornithonyssus* has a rounded posterior margin). The shield usually occupies more than half of the dorsal surface and its surface is reticulated (not striated) with a network of up to 5 fine lines. The sternal shield is short and crescent-shaped with 1-2 pairs of setae (while that of *Liponyssoides* is hexagonal with 3 pairs of setae). The genitoventral shield is rounded posteriorly and has one pair of setae. The anus is located in the posterior half of the anal plate which is broadly triangular with 3 setae. The anteroventral idiosoma gives rise to 4 pairs of long powerful legs, each with 6 segments (coxa, trochanter, femur, genu, tibia, and tarsus) with the last segment having a stalked pretarsus with an expanded pretarsal apparatus (ambulacrum) bearing paired claws and an empodium (pad-like pulvillus). The coxae lack spurs and most segments have long setae arranged in characteristic patterns (chaetotaxy often species-specific). Adults have 2 lateral respiratory openings (stigmata) located between the second and fourth pairs of legs (Mesostigmata), often with elongated processes (peritremes). Adult mites exhibit sexual dimorphism, with males being smaller and exhibiting more extensive sclerotization with fusion of sternal and genitoventral elements forming an intercoxal sternogenital (holoventral) shield in many cases. The mouthparts of adult males have broader chelicerae, enlarged chelae and long spermadactyla on the movable digits so they may function as gonopods to transfer sperm to females during mating (process known as neopodospermy). Mature males have paired testes with tubular vas deferens leading to the ejaculatory duct and long sheathed aedeagus (penis). The genital orifice (gonopore) is conspicuous and located presternally. Mature females have 2 ovaries (with ovarioles) which are connected by tubular oviducts to the uterus (with a muscular accessory shell-gland) and vagina (with a bursa copulatrix to receive sperm during mating, and a spermathecae to store sperm after mating). The female gonopore is located anteroventrally and has an epigynal shield.

Site of infection: These non-burrowing mites are found as ectoparasites on a wide range of birds and occasionally on mammals. Infestations have been reported on 25 species of birds belonging to 20 passerine families and 13 non-passerine families in 12 orders (including seabirds, shorebirds, woodpeckers, doves, fowl and birds of prey). Several species may also infest mammals, with mites recorded on miscellaneous mammals belonging to 8 families in 6 orders (including rodents, lagomorphs, carnivores, horses, bats and humans). All mite species show a strong preference for avian hosts, and several reports indicate that they are often unable to reproduce when feeding on mammalian blood. Nymphs (both instars) and adults (both sexes) feed on hosts and may be found anywhere on the skin, but they tend to target the breast, legs and vent of birds (preferring fluffy downy feathered areas), and the belly, back, limbs and muzzle of mammals (including the arms and chests of humans).

Pathogenesis: Dermanyssid mites are haematophagous parasites that use their long piercing mouthparts to suck blood from their vertebrate hosts. Light infestations may remain subclinical but heavier infestations often cause clinical disease (acariasis) characterized by anaemia and inflamed skin lesions. Nymphs and adults locate hosts and feed rapidly every few days, with adults taking up to 0.2 µl of blood each meal. Heavy infestations may involve thousands of mites resulting in significant blood loss leading to anaemia (evident in poultry as pale combs and wattles). Mites cause local tissue trauma at bite sites producing irritation, pain, pruritus, dermatitis (inflammation) with erythema (redness) and oedema (swelling), pustule formation, scaly skin with hyperpigmentation, scab formation, and plumage damage (dirty discolouration, feather loss). Infestations cause hosts considerable biting stress with restlessness, weakness, poor condition, excessive grooming (preening, biting, scratching, rubbing) and dishevelled appearance. The red mite, *D. gallinae,* is a significant pest in the poultry industry with infestations leading to serious production losses through reduced egg production, smaller egg size, poor egg quality, reduced weight gains despite increased feed and water intake, decreased reproductive potential in males and diminished disease resistance contributing to mortalities in young and ill birds. Mite numbers on poultry increase for 4-6 months and then tend to plateau or drop. Infestations in layer sheds can increase up to 25,000-50,000 mites per bird, and in extreme cases treble that number, resulting in significant morbidity and mortality. Mites may also opportunistically infest humans, mainly poultry workers or residents of houses with bird nests in the roof or under the eaves (starving mites migrate indoors seeking food sources). Such infestations cause dermatological problems varying in severity, with inflammation, pruritus, rashes, papule formation and skin crusting. Domestic and companion animals (such as horses, dogs and cats) may also develop papular skin lesions, particularly in the vicinity of poultry sheds or yards. *Dermanyssus* spp. may also serve as vectors for the transmission of various infectious microbial diseases, including proteobacteria causing pasteurellosis (fowl cholera), coxiellosis (Q fever), enterobacteria causing salmonellosis and escherichiosis, rickettsial bacteria causing avian spirochaetosis, and viruses causing fowl pox, avian influenza and possibly equine encephalitis. Many microbes multiply in mite tissues, most survive mite metamorphosis (trans-stadial transmission) and some may be transferred to mite eggs (trans-ovarian transmission).

Developmental cycle and mode of transmission: *Dermanyssus* spp. undergo hemimetabolous (incomplete) metamorphosis where eggs hatch larvae which moult to nymphs and then adults. Transmission between hosts is often via fomites as mites spend most of the time in the surrounding environment although transmission by direct host-to-host contact may also occur. It has been suggested that 2 ecological species-groups occur: the *gallinae*-group comprising species that are nest-dwelling (nidicolous) and have broad host specificities; and the *hirsutus*-group containing species that spend more time on their hosts and have narrow host specificities. Gravid females lay eggs in the external environment, predominantly in nests, litter and cracks/crevices in dwellings. The eggs hatch

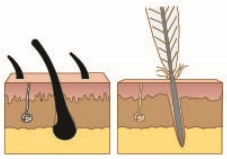
in 1-3 days releasing hexapod (6-legged) larvae which do not feed but moult in 17-24 hours to form octopod (8-legged) first-stage nymphs (protonymphs). The protonymphs crawl onto hosts to feed on blood before detaching and moulting in 1-2 days to form second-stage nymphs (deutonymphs). The deutonymphs locate hosts and feed on blood (whereas macronyssid deutonymphs do not feed). When replete, they detach and moult in 1-2 days to form adults which then seek hosts on which to feed. Mites spend most of the time off hosts in the surrounding environment and generally only make contact to feed rapidly over 30-60 minutes every 2-3 days. During the daytime, mites lie concealed in refugia (cracks and crevices) to rest and reproduce. They are often found in clusters formed by thigmokinesis: with larvae in the centre, females on the outside, and males on top. Adult mites are quite hardy and may survive in the environment for up to 34 weeks without feeding. Most species are nocturnal and feed on birds during the night, although starving mites will feed during the day and will attack any both birds and mammals. Mating takes place off hosts and involves the transfer of spermatophores (packets of around 200 sperm) from males to females. Fertilized females lay 4-8 eggs 12-24 hours after each blood meal, producing up to 8 clutches totalling 30-50 eggs in their lifetime. The whole life-cycle may be completed in as little as 5-17 days, so mite populations can increase very rapidly. Mites prefer mild humid conditions and are susceptible to heat but can survive cold conditions but not freezing. Mite populations tend to increase during the winter months, and decrease over summer. Infestations in wild birds are generally attuned to host breeding seasons, and the presence of nestlings facilitates rapid reproduction with peak mite numbers coinciding with fledging. Higher mite populations develop in layer chickens than in broilers (as layers are kept longer) and in birds kept in less intensive systems (such as barns, free-range and organic farms) where more hiding/resting places are available for mites. Poultry sheds may remain infested for 4-5 months after birds are removed, and mites may be dispersed between farms by the transport of contaminated equipment (crates, egg trays, etc) or the translocation of infested animals (and humans).

Differential diagnosis: Infestations may be suspected on the basis of clinical grounds (skin lesions, inflammation, anaemia, poor condition) but other aetiological agents may cause similar signs/symptoms, including other ectoparasites (such as *Ornithonyssus*). Diagnosis is confirmed by the detection of mites on hosts, with examination techniques involving manual manipulation of coats, plucking plumage/pelage, collecting skin scrapings for caustic digestion, applying adhesive tape to the skin, massaging hosts over blank paper or washing bodies in plastic bags. Any specimens collected may be identified by microscopic examination of their morphological characteristics. Some infestations may be overlooked, however, as the mites are small and feed only intermittently on hosts often at night. Mites are often found at the edges of lesions, particularly those involving flaking or crusted skin. Molecular biological techniques have been used to characterize species (and ratify species-groups) by polymerase chain reaction (PCR) amplification of nuclear (18S, 5.8S and 28S ribosomal RNA, internal transcribed spacers 1 and 2) and mitochondrial (cytochrome c oxidase subunit 1) gene sequences.

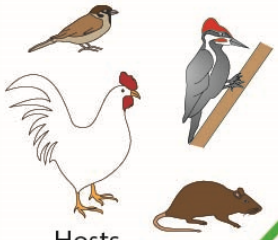
Treatment and control: Incidental infestations on humans are usually treated symptomatically using antihistamines and topically administered steroids to provide relief. Infestations on domestic animals and aviary birds are usually treated using chemical acaricides, but careful attention must be given to any drug contra-indications and with-holding periods applicable to animals destined for human consumption. A range of products are available for topical or systemic use as sprays, baths/dips, dusts/powders, pour-ons, spot-ons, impregnated tags, oral drenches or injectable formulations. Infestations have been successfully treated with organochlorines (lindane), organophosphates (malathion, coumaphos, tetrachlorvinphos, methoxychlor, diazinon), pyrethrin and synthetic pyrethroids (permethrin), carbamates (carbaryl), macrocyclic lactones (ivermectin, moxidectin, selamectin) and some natural products (rotenone). Repeated or prolonged treatment may be required, particularly for generalized infestations, but the use of formulations with long-lasting residual activity helps reduce treatment frequency. There are growing reports of mite populations developing resistance to acaricides (organochlorines, organophosphates, pyrethroids and macrocyclic lactones), so it is recommended that different acaricides be used in cyclic rotation. Residual acaricides may also be applied to bird houses, nests, runs and litter to suppress off-host mite populations, with various agencies recommending organophosphate (dimethoate and fenthion, when birds are not present) or pyrethroid sprays, or carbaryl or lime sulphur powders. Alternatively, birds may be given access to dust baths (silica, diatomaceous earth) which have been shown to adhere to mites resulting in their desiccation. Various preventive strategies may be adopted to break transmission cycles, preferably integrated into holistic pest management programs involving health management (screening, treatment, quarantine, culling), animal husbandry (lower stocking rates, cohort separation, not trimming beaks to preserve self-grooming, manipulating photoperiods to shorten night cycles), environmental management (improved hygiene and sanitation, removal of litter, disinfecting cages, repairing or replacing housing to eliminate crevices, treating with residual acaricides) and wildlife management (excluding wild birds and rodents). Preliminary studies on vaccine development and biological control have suggested that birds may develop some protective immunity with age and that entomopathogenic fungi may suppress mite populations.

Dermanyssus

transmission between hosts by direct contact
or via contaminated fomites

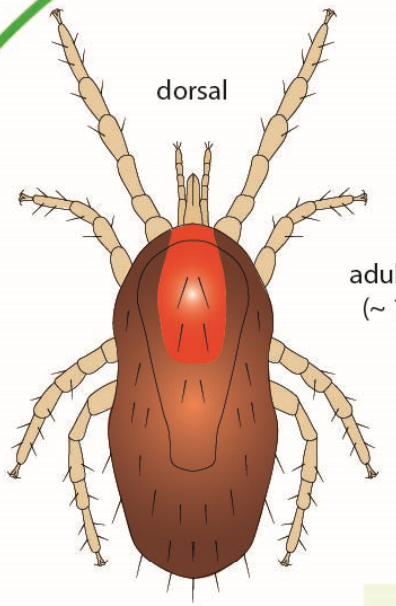


skin
(blood loss,
irritation,
lesions)
(vectors for
infectious
microbial
diseases)

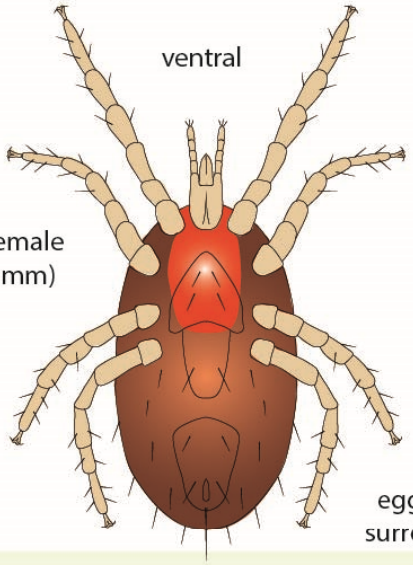


Hosts
(birds, some
mammals)

dorsal



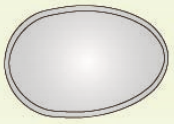
ventral



adult female
(~ 1.5 mm)

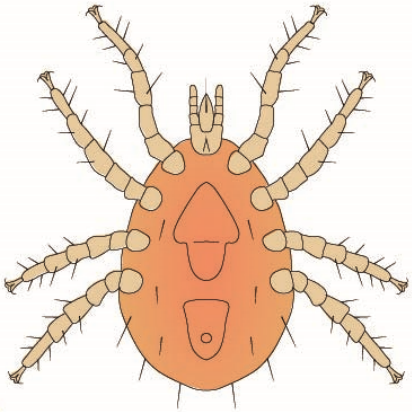
tarsal
elements

eggs laid in
surroundings

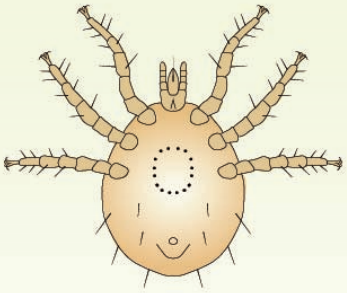


egg
(~ 400 µm)

hatch



nymph
(ventral)
(~ 800 µm)



larva
(ventral)
(~ 500 µm)

larva do
not feed

2 nymphal instars,
(protonymphs,
deutonymphs
(both feed))

transient ectoparasites
(emerge fron refugia to feed on host blood)

Dermanyssus adult

Dermanyssus adult, female with egg

Dermanyssus eggs