

Ornithonyssus
(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. 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. Macronyssid mites are large blood-sucking ectoparasites with long legs, but only the protonymphs and adults feed. Infestations by *Ornithonyssus* spp. may cause scabbing and anaemia in domestic poultry and dermatitis in rodents.

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: Dermanyssioidea (elongate edentate chelicerae, diverse life-styles)
Family: Macronyssidae (blood-sucking ectoparasites, only protonymph and adults feed, relatively long legs)
Genus: *Ornithonyssus* (parasitic on skin/feathers of birds)
Species: various species cause dermatitis and anaemia in poultry and rodents

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 (capitulum). 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 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, Cercomegastina, 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 Veigaiioidea). 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 Macronyssidae contains blood-sucking mites that are parasitic as later-stage nymphs and adults on vertebrates, mostly bats and rodents, and a few genera infesting birds or reptiles. They are often nidicolous and leave their hosts to lay eggs around dens, burrows and nests. The mites are comparatively large and long-legged, with a pronounced ridge or spur on the palpal trochanter. Some 34 genera are recognized, with 8 placed in the subfamily Liponyssinae (*Bdellonyssus*, *Chiroptonyssus*, *Hirstesia*, *Kolenationyssus*, *Liponyssus*, *Neoichoronyssus*, *Neoliponyssus*, *Radfordiella*), 4 in the subfamily Ornithonyssinae (*Ophionyssus*, *Ornithonyssus*, *Pellonyssus*, *Steatonyssus*), 2 in the subfamily Macronyssinae (*Macronyssus*, *Macronyssoides*) and 20 genera unplaced (*Acanthonyssus*, *Arachnyssus*, *Argitis*, *Chiroecetes*, *Coprolactistus*, *Cryptonyssus*, *Draconyssus*, *Endophionyssus*, *Glauconyssus*, *Lagidonyssus*, *Lepidodorsum*, *Lepronyssoides*, *Mitonyssoides*, *Mitonyssus*, *Nycteronyssus*, *Oudemansiella*, *Parichoronyssus*, *Synasponyssus*, *Thigmonyssus*, *Trichonyssus*). The genus *Ornithonyssus* is characterized by adult mites with large dorsal plates with pointed posterior margins but not nearly covering the body, well-defined narrowing genital plates (like *Dermanyssus*), oval anal plates (more elongate in *Dermanyssus*), long legs grouped anteriorly and ending in paired claws with a pulvillus, and short stout chelicerae (not long whip-like in *Dermanyssus*) with toothless blade-like chelae at their tips. The genus contains over 30 species that infest the plumage of birds or the pelage of small mammals (especially rodents and bats). Several species, esp. *O. sylviarum* (northern fowl mite) and *O. bursa* (tropical fowl mite), feed on chickens and other caged and wild birds (opportunistically feeding on mammals, including humans) and some, notably *O. bacoti* (tropical rat mite) infests a wide range of rodents and other mammals throughout temperate regions of the world, sometimes associated with anaemia, pruritus and alopecia.

<i>Ornithonyssus</i> species	Hosts	Clinical signs	Distribution
<i>O. acrobates</i>	Diprotodontia: acrobatid (feathertail glider)		Australia
<i>O. africanus</i>	Chiroptera: rhinolophid (Geoffroy's horseshoe bat)		Africa
<i>O. aridus</i>	Rodentia: sciurid (white-tailed antelope squirrel)		North America
<i>O. bacoti</i> (syn. <i>Leiognathus</i> , <i>Liponyssus</i> , <i>Macronyssus</i> , <i>Haemogamasus</i> <i>sanguineus</i>) (tropical rat mite)	Rodentia: murid (black rat, brown rat, African grass rat, house mouse, typical striped grass mouse, four-striped grass mouse, Dalton's mouse, Natal multimammate mouse, Indian gerbil, great gerbil, Persian jird), cricetid (cotton mouse, golden mouse, northern pygmy mouse, northern grasshopper mouse, brush mouse, canyon mouse, cactus mouse, white-footed mouse, white-ankled mouse, Pinyon mouse, Florida mouse, Oldfield mouse, deer mouse, eastern meadow vole, eastern wood rat, southern plains wood rat, hispid cotton rat, marsh rice rat), nesomyid (African tree mouse, gerbil mouse, Mexican spiny pocket mouse), heteromyid (Ord's kangaroo rat, hispid pocket mouse, Great Basin pocket mouse), sciurid (least chipmunk, eastern grey squirrel, Mexican ground squirrel, Townsend's ground squirrel), zapodid (Preble's meadow jumping mouse); Eulipotyphla: soricid (greater red musk shrew, swamp musk shrew, African giant shrew); Didelphimorphia: didelphid (Virginia opossum); Lagomorpha: leporid (eastern cottontail, marsh rabbit); Carnivora: canid (gray fox), herpestid (Cape gray mongoose), mephitid (striped skunk, eastern spotted skunk), procyonid (raccoon); Primates: hominid (human)	irritation, dermatitis, anaemia	worldwide
<i>O. benoiti</i>	Rodentia: anomalurid (pygmy scaly-tailed flying squirrel)		Africa
<i>O. brasiliensis</i> (syn. <i>Liponyssus</i> , <i>Bdellonyssus</i>)	Rodentia: caviid (Brazilian guinea pig), cricetid (marsh rat, Amazonian marsh rat, scaly-footed water rat, hispid hociبدو, blackish grass mouse), echimyid (Fischer's guira); Didelphimorphia: didelphid (big-eared opossum, Brazilian gracile opossum); Lagomorpha: leporid (common tapeti); Carnivora: mustelid (greater grison); Primates: hominid (human)		South America
<i>O. bursa</i> (syn. <i>Liponyssus</i> , <i>Leiognathus</i>) (tropical fowl mite, bird mite, starling mite)	Galliformes: phasianid (chicken, turkey), Anseriformes: anatid (duck); Columbiformes: columbid (pigeon); Coliiformes: coliid (white-backed mousebird); Passeriformes: malaconitid (crimson-breasted shrike, bokmakierie), passerid (sparrow), sturnid (common starling, red-winged starling, mynah); Accipitriformes: accipitrid (Eurasian sparrowhawk, besra, swallow-tailed kite, Australian black-shouldered kite, small kite), cathartid (turkey vulture); Falconiformes: falconid	irritation, matting, scabbing, anaemia (plus vectors for fowlpox, Newcastle disease,	India, China, Africa, Australia, Americas

	(Australian kestrel); Strigiformes: strigid (Indian scops-owl, barn owl); Rodentia: cricetid (white-footed mouse, eastern meadow vole)	chlamydiosis)	
<i>O. campester</i>	Chiroptera: emballanurid (common sheath-tail bat), vespertilionid (hoary wattled bat, yellow-lipped bat)		Australia
<i>O. capensis</i>	Macroscelidia: macrosclidid (eastern rock elephant shrew)		Africa
<i>O. coendou</i>	Rodentia: erethizonitid (Andean porcupine)		South America
<i>O. conciliatus</i>	Chiroptera: phyllostomid (flat-faced fruit-eating bat)		Central America
<i>O. cornutus</i>	Chiroptera: molossid (Egyptian free-tailed bat)		Egypt
<i>O. costai</i>	Rodentia: spalacid (Middle-East blind mole-rat)		Israel
<i>O. dasyuri</i>	Dasyuromorphia: dasyurid (eastern quoll)		Australia
<i>O. desultorius</i> (syn. <i>Cryptonyssus</i>)	Chiroptera: vespertilionid (big brown bat, cave myotis, California myotis, canyon bat)		North America
<i>O. flexus</i>	Chiroptera: vespertilionid (little brown bat)		North America
<i>O. galagus</i>	Rodentia: glirid (woodland dormouse); Primates: galagid (Senegal bush baby)		Africa
<i>O. garridoi</i>	Rodentia: echimyid (prehensile-tailed hutia)		Cuba
<i>O. hoogstraali</i>	Chiroptera: molossid (European free-tailed bat)		Egypt
<i>O. hypertrichus</i>	Rodentia: cricetid (cactus mouse, white-ankled mouse, Pinyon mouse)		North America
<i>O. iheringi</i>	Accipitriformes: accipitrid (sharp-shinned hawk); Cingulata: chlamyphorid (dwarf armadillo), dasypodid (armadillo)		Europe, South America
<i>O. latro</i>	Chiroptera: vespertilionid (eastern forest bat)		Australia
<i>O. longisetosus</i>	Didelphimorphia: didelphid (Linnaeus's mouse opossum)		South America
<i>O. lukoschusi</i>	Rodentia: glirid (woodland dormouse)		Africa
<i>O. matogrosso</i> (syn. <i>Neoichoronyssus</i> , <i>Hirstionyssus</i> , <i>Lepronyssoides</i>)	Rodentia: echimyid (punare)		South America
<i>O. monteiroi</i> (syn. <i>Liponyssus</i> , <i>Bdellonyssus</i> , <i>O. lutzi</i>)	Rodentia: cricetid (cursor grass mouse, hairy-tailed bolo mouse, terraced rice rat, yellowish rice rat, scaly-footed water rat, Robert's hociبدو), caviid (guinea pig, Brazilian guinea pig), echimyid (Fischer's guiara, Pacific spiny rat), murid (black rat, brown rat)		South America
<i>O. nitedulae</i>	Rodentia: glirid (forest dormouse)		Israel
<i>O. noeli</i>	Rodentia: echimyid (hutia)		Cuba
<i>O. nyctinomi</i>	Chiroptera: molossid (free-tailed bat)		Africa
<i>O. parvus</i>	Rodentia: hystricid (Philippine porcupine)		Philippines
<i>O. pavlovskii</i>	Rodentia: glirid (hazel dormouse)		Romania
<i>O. petauri</i>	Diprotodontia: petuarid (sugar glider)		Australia
<i>O. pereirai</i> (syn. <i>Liponyssus</i> , <i>Lepronyssoides</i>)	Rodentia: caviid (rock cavy, Spix's yellow-toothed cavy), cricetid (hairy-tailed bolo mouse, Atlantic forest climbing mouse, terraced rice rat, angular hociبدو), echimyid (highlands punare), murid (black rat); Didelphimorphia: didelphid (gray short-tailed opossum)		South America
<i>O. pipistrelli</i> (now <i>Cryptonyssus</i>)	Chiroptera: vespertilionid (pond bat)		Russia
<i>O. praedo</i>	Rodentia: murid (fawn-footed mosaic-tailed rat)		Australia
<i>O. roseinnesi</i>	Rodentia: murid (Namaqua rock rat, four-striped grass mouse)		Africa
<i>O. simulatus</i>	Afrosoricida: tenerecid (least shrew tenrec)		Madagascar
<i>O. spinosa</i>	Chiroptera: vespertilionid (New Zealand long-tailed bat)		New Zealand
<i>O. steidii</i>	Rodentia: spalacid (lesser mole-rat)		Bulgaria
<i>O. stigmaticus</i>	Chiroptera: emballanurid (yellow-bellied sheath-tailed bat)		Australia
<i>O. sylviarum</i> (syn. <i>Liponyssus americanus</i> , <i>pacificus</i> , <i>O. banksi</i>) (northern fowl mite)	Galliformes: phasianid (chicken, turkey); Passeriformes: cisticolid (Karoo prinia), fringillid (canary), motacillid (white wagtail), muscicapid (ant-eating chat), pycnonotid (common bulbul); Accipitriformes: accipitrid (northern goshawk); Falconiformes: falconid (Australian kestrel); Strigiformes: strigid (barn owl); Rodentia: heteromyid (Mexican spiny pocket mouse), murid (house mouse, black rat), sciurid (yellow-bellied marmot, alpine chipmunk); Lagomorpha: leporid (mountain	irritation, matting, scabbing, anaemia (plus vectors for fowlpox, Newcastle disease,	temperate zones

	cottontail); Chiroptera: vespertilionid (big brown bat, cave myotis); Primates: hominid (human)	chlamydiosis, St Louis encephalitis, western equine encephalomyelitis)	
<i>O. taphozous</i>	Chiroptera: emballonurid (common sheath-tailed bat)		Australia
<i>O. vitzthumi</i> (syn. <i>Liponyssus</i> , <i>Bdellonyssus</i>)	Rodentia: cricetid (montane grass mouse, gray leaf-eared mouse, vesper mouse, hairy-tailed bolo mouse, black-footed pygmy rice rat, hispid hociúdo, long-nosed hociúdo), caviid (common yellow-toothed cavy), echimyid (Fischer's guiana), sciurid (Bolivian squirrel)		South America
<i>O. wernecki</i> (syn. <i>Liponyssus</i> , <i>Neoichoronyssus</i>)	Rodentia: murid (brown rat), cricetid (hispid cotton rat); Didelphimorphia: didelphid (white-eared opossum, big-eared opossum, Virginia opossum)		South America

Parasite morphology: *Ornithonyssus* spp. form 4 different types of morphological developmental stages; namely, eggs, larvae (one instar), nymphs (2 instars), and adults (both males and females). Eggs are sticky white ovoid-ellipsoidal stages measuring 0.2-0.3 mm in length. Larvae have ovate flattened bodies measuring 0.2-0.3 mm long, each with 3 pairs of anteroventral legs and a small anterior gnathosoma (head or capitulum). They are grey-white in colour and have little to no sclerotization and no external genitalia. Nymphs have larger longer bodies that are more ellipsoidal in shape measuring up to 0.3-0.4 mm in length. They have 4 pairs of long tapering legs which appear to be arranged in 2 sets, the first 2 pairs directed anteriorly and the hind 2 pairs directed posteriorly. There are 2 nymphal instars (the first known as protonymphs, the second as deutonymphs) which exhibit progressive differentiation of sclerotized shields with each moult. Nymphs do not have genital openings but they possess small epigynal shields. The anterior gnathosoma bears conspicuous mouthparts flanked by long sensory palps. Adult mites have ellipsoidal bodies which are flattened ventrally and slightly convex dorsally. They usually range in length from 0.5-1.0 mm, although mature specimens of some species may be as large as 2 mm long. They are opaque grey-white but become reddish-brown to black when engorged on host blood. They have 2 distinct tagma, a small anterior gnathosoma and the larger posterior idiosoma (body). The gnathosoma in these sucking mites bears long stylet-like mouthparts (not claw-like mouthparts like burrowing mites) that project forwards when fully extended but are retracted when not in use. The mouthparts (chelicerae and hypostome) are flanked by a pair of sensory palps, each composed of 5-6 segments and terminating in a 2-tined claw (apotele). Like other mesostigmatid mites, the basal segments of the palps are fused to form a basis capitulum which encloses the chelicera and give rise to the hypostome. The chelicerae are elongate and have 3 segments, the first segment being the longest in macronyssids (while the second segment is the longest in dermanyssids). The third segment terminates in stylet-like chelae (pincers) with distinct fixed and movable digits without excrescences (cf. dermanyssid chelicerae are whip-like with highly reduced chelae). The oral opening (mouth) comprises a dorsal rostrum, ventral buccal cone and an unbarbed hypostome (barbed in ticks). The alimentary tract consists of a tubular foregut (pharynx and oesophagus connected to salivary glands), a saccular midgut (branched ventriculus with gastric caeca) and a short tubular hindgut (intestines with excretory Malpighian tubules connected to rectum and subterminal anus). The idiosoma narrows posteriorly (slightly in *O. bursa*, considerably in *O. sylviarum*) and is setate (more than *Dermanyssus*) with many long setae. Species are often differentiated by their distinctive chaetotaxy (number, position and size of setae). During feeding, the idiosoma does not usually expand (whereas it does in ticks). Adult mites possess a sclerotized dorsal shield and 3 ventral shields (sternal, genitoventral and anal). The dorsal shield is oval-pyriform and occupies less than a third of the dorsal surface and is distinctly pointed posteriorly (whereas that of *Dermanyssus* is larger, smoothly tapered and posteriorly truncated). The shield surface is reticulated (not striated) and bears several long setae. The sternal shield may be entire or eroded, with 1-3 pairs setae (females typically with 2 pairs). The genitoventral shield may be tongue- or knife-shaped with 0-1 pairs of setae (while that of *Dermanyssus* is posteriorly rounded and bears one pair of setae). The anus is located in the anterior half of the anal shield which may be oval to elongate (longer than *Dermanyssus*) and bears 3 circum-anal setae. The ventral idiosoma gives rise to 4 pairs of long powerful legs arranged in 2 anteroventral sets (like nymphs) but with different pairs arising from the sternal plate (first 2 pairs for *O. sylviarum*, first 3 pairs for *O. bursa*). The first pair of legs (forelegs) are generally longer and slenderer than the others. Each leg is jointed with 6 main segments (coxa, trochanter, femur, genu, tibia and tarsus), although the tarsus has a stalked pretarsus with an expanded pretarsal apparatus (ambulacrum) bearing paired claws and an empodium (pad-like pulvillus). Like all Mesostigmata, the coxae are not fused to the ventral body and the respiratory openings (stigmata) are located posteriorly between the second and fourth legs, often with elongated processes (peritremes). Adult mites exhibit moderate sexual dimorphism, with males being slightly smaller in body size and having a holoverital shield (fusion of sternal and genitoventral shields). They have 2 testes with tubular vas deferens connected to the ejaculatory duct and long sheathed chitinous aedeagus (penis). The genital opening (gonopore) is located on the ventral midbody between the last 2 pairs of legs, and mating involves direct transfer of sperm to the female via copulation. Females have 2 ovaries (with ovarioles) connected by tubular oviducts to the uterus (with a muscular shell-gland) and vagina (with accessory organs for sperm storage (known as the bursa copulatrix, or spermathecae)). The gonopore is located on the ventral midbody and has an epigynal shield with a narrowly rounded posterior.

Site of infection: *Ornithonyssus* spp. are non-burrowing ectoparasites of vertebrate hosts (mammals and birds). While all developmental stages occur amongst the pelage/plumage of their hosts, only the protonymph and adult stages feed by sucking host blood. Many *Ornithonyssus* spp. are uncommon and have only been reported on a few host species, whereas a few species are much more common and have broader host ranges being found on a variety of mammals and birds. In total, 41 *Ornithonyssus* spp. have been recorded on mammals belonging to 35 families in 12 orders (mostly rodents, but also bats, insectivores, carnivores, lagomorphs and primates, incl. humans). Three species (*O. bursa*, *O. sylvarum* and *O. iheringi*) have been recorded a few mammals, but mostly on birds belonging to 8 passerine families and 8 non-passerine families in 7 orders (waterfowl, landfowl, pigeons, mousebirds and birds of prey). While infestations may occur over the whole body of their hosts, feeding stages are regularly found on the head, neck, chest, abdomen and extremities of mammals, and near the bases of feathers of birds, particularly around the vent and along the back.

Pathogenesis: Mite infestations may cause a disease condition known as acariasis, with non-burrowing surface mites typically causing skin lesions at feeding sites, blood loss and poor condition (whereas burrowing mites may cause severe dermatitis or mange). Protonymphs and adults of *Ornithonyssus* spp. use their long piercing-sucking mouthparts to penetrate the skin and take rapid meals from underlying blood vessels. Several species cause inflammation and anaemia in poultry and rodents, some even biting humans causing small irritating skin lesions and sometimes allergic reactions with intense skin inflammation. Heavy infestations may cause significant blood loss resulting in anaemia and even death due to exsanguination, particularly in poultry (in extreme infestations, mites have been reported to take up to 6% of the blood volume daily in chickens). Mite bites cause traumatic damage to the skin with irritation, inflammation (erythema, oedema), pruritus, papule formation, rough scaly skin with hair/feather loss, crusting and scabbing, particularly around the vent of birds. Surrounding feathers often develop a dirty matted grey-black appearance due to accumulations of debris consisting of mites, mite faeces, mite eggs, mite exuvia (cast skins), dried blood and scabs. Infested animals exhibit biting stress with restlessness, depressed appetites, weakness, debility and exaggerated grooming behaviours (preening, biting, scratching and rubbing). The species *O. bursa* (tropical fowl mite) and *O. sylvarum* (northern fowl mite) are notorious pests of poultry with significant production losses due to reduced meat and egg production. Infestations are worse in egg layer and breeder operations where birds are maintained for longer periods. Mite populations are also higher on birds that have had their beaks trimmed as they are less able to self-groom. The species *O. bacoti* (tropical rat mite) is recognized as a serious pest in laboratory rodent colonies with heavy infestations causing morbidity (anaemia, pruritic papular dermatitis, soiled fur, alopecia) and occasional deaths. Infestations of humans are usually incidental to handling infested animals or having starving mites from recently-vacated nests or burrows invade households seeking hosts. There is growing evidence that animals may develop an age-related acquired immunity as mite populations decline in adulthood although low numbers may persist for life. Studies have indicated that chronic infestations result in thickened hardened skin due to host immune responses making it more difficult for mites to feed with their small mouthparts. Mites have also been shown to act as vectors for the transmission of various infectious diseases, including bacteria causing chlamydiosis, and viruses causing fowl-pox, Newcastle disease, St Louis encephalitis, western equine encephalomyelitis and Korean (epidemic) haemorrhagic fever. Experimental studies have also confirmed that mites may carry rickettsial bacteria associated with murine typhus and rickettsial pox, coccobacilli associated with plague and tularaemia, and viruses associated with Coxsackie diseases, but their roles in disease transmission are unclear.

Developmental cycle and mode of transmission: Like all mites, *Ornithonyssus* spp. undergo hemimetabolous (incomplete) metamorphosis where eggs hatch larvae which moult to nymphs and then adults. Transmission between hosts is by direct contact or via fomites as mites spend most of the time on hosts or in their homes (nests/burrows). Gravid females lay eggs either on their hosts around the bases of feathers (e.g. *O. sylvarum*) or off hosts in litter in nests/burrows (e.g. *O. bursa*, *O. bacoti*). The eggs do not survive for longer than 10 days and usually hatch within 1-3 days releasing 6-legged larvae. The larvae do not feed and rapidly moult to the first nymphal instar (protonymph) in about 8 hours. The protonymphs move to feeding sites on suitable hosts and feed intermittently on host blood for 4-7 days before moulting to the second nymphal instar (deutonymphs, some texts erroneously calling them tritonymphs). The deutonymphs do not feed on host blood (whereas those of dermanyssids do) and they moult in about 5 days to become adult mites. Adults feed rapidly and intermittently on host blood and usually leave the host after each bloodmeal to rest and reproduce in the surrounding environment, particularly nests/burrows (nidicolous behaviour). They are active mites with powerful legs and can crawl several hundred metres to locate hosts. Adults usually survive for 1-4 weeks off hosts, sometimes up to 120 days under favourable conditions. Female mites may live for up to 70 days, feeding every 2-3 days either diurnally (e.g. *O. bursa*) or nocturnally (e.g. *O. sylvarum*). They lay small numbers of eggs (1-5) after each bloodmeal, totalling up to 100 eggs over their life-spans. The whole life-cycle may be completed in as little as 5-16 days, so mite populations can quickly escalate (up to 20,000 mites per host in 9-10 weeks). Infestations are more common when food sources are regularly available (e.g. gregarious hosts, crowded farmed animals, nestling birds) and when warm moist environmental conditions prevail (e.g. in subtropical regions, or during spring in temperate regions).

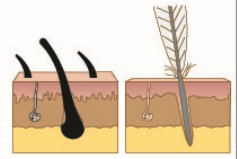
Differential diagnosis: Infestations may be suspected on clinical grounds (skin lesions, anaemia, poor condition, dirty plumage/coat) but other aetiological agents must be considered. Diagnoses are generally made by direct detection of mites on the hosts, often visible due to their contrasting colour following feeding. Mites are usually present on birds during the daylight (unlike *Dermanyssus*), particularly around the bases of feathers and the cloaca, sometimes adhering to recently laid eggs. Skin scrapings may be collected for microscopic examination after caustic digestion (usually 10% potassium hydroxide), but test sensitivity is low

especially in light or transient infestations of those involving cryptic species. Alternatively, mites may be collected by plucking, combing or brushing hairs/feathers, by applying adhesive tape to the skin, by massaging live animals over blank paper, or by washing dead animals in plastic bags. Any specimens collected should be examined microscopically and identified on the basis of their morphological characteristics. Molecular biological techniques have been used to characterize species following the polymerase chain reaction (PCR) amplification of nuclear (18S and 28S ribosomal RNA) and mitochondrial (16S ribosomal RNA) gene sequences.

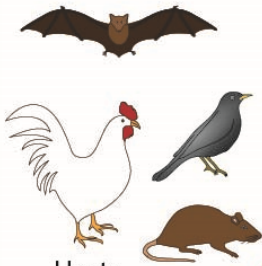
Treatment and control: Clinical infestations are treated by the application of chemical acaricides, including sulphur dusts, organochlorines (dichloro-diphenyl-trichloroethane (DDT), lindane), organophosphates (tetrachlorvinphos, dichlorvos, malathion), pyrethrin and synthetic pyrethroids (permethrin), carbamates (carbaryl), macrocyclic lactones (ivermectin, selamectin), arylpyrazole (fipronil), isoxazolines (fluralaner), spinosyns (spinosad), some natural products (rotenone) and even some essential oils (thyme, hemp, ajowan, garlic). Treatments may be applied topically as sprays, baths, dusts, or emulsions, or systemically as spot-ons, pour-ons, oral drenches or in-water medications. The strategic and regular treatment of closed animal populations can reduce or eliminate infestations, but there is growing concern about the development of acaricide resistance in some mite populations, particularly to organochlorines and some organophosphates and macrocyclic lactones. Some success has been reported in reducing mite populations in poultry by providing dust-baths (diatomaceous earth, kaolin clay) which acts to desiccate mites on contact. Incidental infestations in humans also benefit greatly by the provision of symptomatic relief in the form of antipruritics and anti-inflammatories (corticosteroids and antihistamines). Various preventive strategies may be adopted to help break transmission cycles through improved health management (regular screening, treatment, quarantine, culling), sensible animal husbandry (avoid over-crowding, separate cohorts, cease beak trimming to allow self-grooming), environmental decontamination (proper sanitation of fomites, frequent removal of litter and/or treatment with residual acaricides (e.g. pyrethroids), cleaning and disinfection of equipment and roosts, leaving bird houses empty for at least 4 weeks in hot weather or 8 weeks in cooler weather, removing bird nests in roofs and eaves) and wildlife management (exclude wild animals using barriers, trapping or hunting, routine vermin control). Preliminary studies on biological control have shown that the topical application of entomopathogenic fungi (*Beauveria*) reduced mite numbers on infested birds. Vaccination options should also be explored as animals have been shown to develop an immune-mediated resistance with age following persistent natural exposure. Studies on poultry have also indicated that mite resistance may be a heritable trait that could be incorporated into selective breeding programs.

Ornithonyssus

transmission between hosts by direct contact or via contaminated fomites



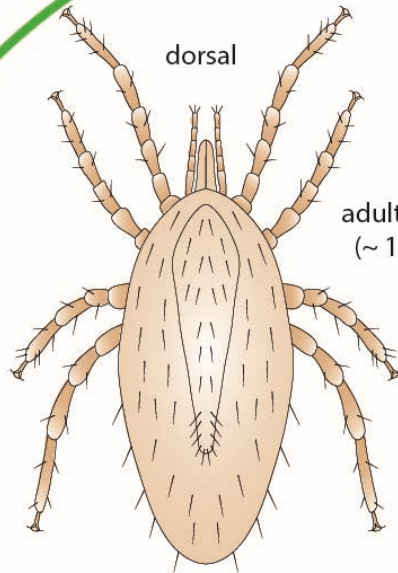
skin
(blood loss,
dermatitis,
lesions)



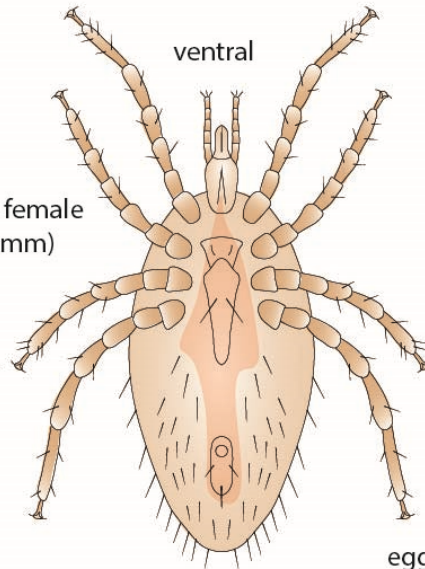
Hosts
(birds,
mammals)



tarsal
elements



dorsal



ventral

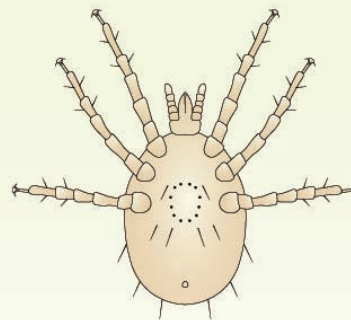
adult female
(~ 1 mm)

eggs laid on host
or surroundings



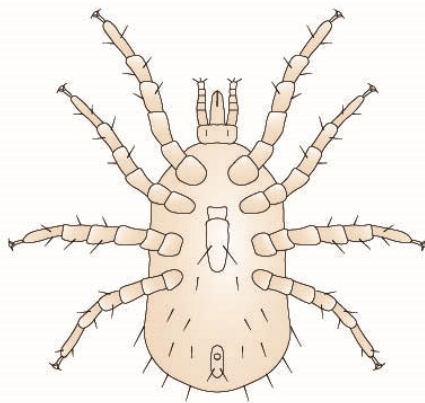
egg
(~ 200 μ m)

hatch



larva
(ventral)
(~ 300 μ m)

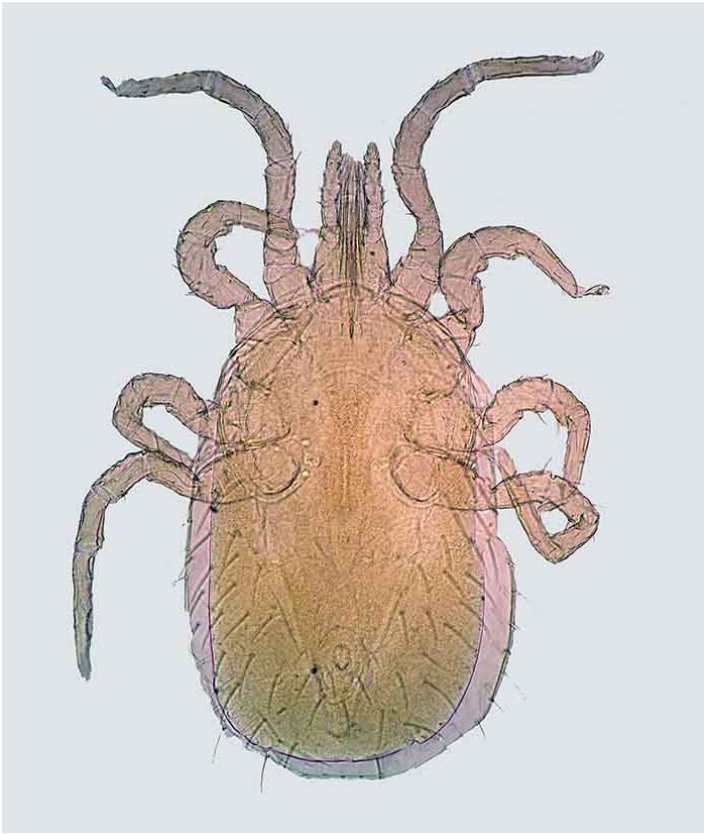
larva do
not feed



nymph
(ventral)
(~ 400 μ m)

[2 nymphal instars,
protonymphs (which feed)
deutonymphs (do not feed)]

transient ectoparasites (most nidicolous,
emerge from nest/burrow to feed on host blood)



Ornithonyssus adult



Ornithonyssus eggs