Myocoptes
(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). Listrophorid mites have a distinct dorsal shield and their legs are modified for grasping hairs of fur-bearing mammals. Infestations by *Myocoptes musculinus* may cause dermatitis (myocoptic mange) in wild and laboratory mice.

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:	Sarcoptoidea (mites associated with mammals, ecto- or endo-parasitic)
Family:	Myocoptidae (parasitic on rodents, some legs adapted as pincers)
Genus:	*Myocoptes* (parasitic on skin/hair of mice)
Species:	*M. musculinus* causes myocoptic mange in mice

Parasite biodiversity and host range: Most Metazoa are multicellular triploblastic animals with differentiated tissues, many being bilaterally symmetrical with a body cavity. Most invertebrate animals are protostomes as their embryonic development involves spiral determinate cleavage. Those that moult their external cuticles during their life-cycles (process known as ecdysis) are grouped together in the unique clade Ecdysozoa, including the nematodes (roundworms), onychophorans (velvet worms), tardigrades (water bears) and arthropods (myriapods, chelicerates, crustaceans and hexapods). Arthropods have small segmented bodies encased in chitinous exoskeletons with articulated limbs. Most species are free-living in terrestrial and aquatic habitats, although a small range are ectoparasitic on other animals, some feeding on the blood or skin of vertebrates. Five subphyla are recognized: Chelicerata, Crustacea, Hexapoda, Myriapoda and Trilobita. The chelicerates typically have appendages (chelicerae) in the form of pincers or fangs anterior to the mouthparts, 2 body parts (cephalothorax and abdomen), but no antennae or wings. Three classes are recognized: Arachnida (spiders and allies), Merostomata (horseshoe crabs) and Pycnogonida (sea spiders). Arachnids have 8 legs, slit sensilla and life-cycles involving incomplete metamorphosis whereby larvae and nymphs resemble adults. They are classified in 4 orders: Acari (acarines), Araneae (spiders), Opiliones (harvestmen) and Scorpiones (scorpions). The Acari comprises the ticks and mites which have saccular bodies and mouthparts confined to an anterior gnathosoma. Four major groups are recognized primarily on the location of their respiratory stigmata (called spiracles in insects): ixodid ticks (posterior Metastigmata), gamesid mites (middle Mesostigmata), trombidiform mites (anterior Prostigmata) and sarcoptiform mites (without stigmata = Astigmata).

Major parasitic families	Biodiversity	Hosts	Parasitic stages	Pathogenesis	Disease transmission
Superorder: Parasitiformes (ticks and some mites, with posterior stigmata)					
Order: Ixodida [Metastigmata] (ticks, macroscopic, stigmata posterior to legs) [3 families]					
Argasidae (soft ticks)	5 genera, 193 species	birds, mammals	larvae, nymphs, adults	blood-sucking	viral, bacterial
Ixodidae (hard ticks)	14 genera, 705 species	birds, mammals	larvae, nymphs, adults	blood-sucking, paralysis	viral, bacterial, protozoal
Order: Mesostigmata [Gamasida] (gamesid mites, stigmata between 2nd & 4th legs) [100 families, 662 genera, 5,360 species]					
Macronyssidae (sucking mites)	26 genera, 127 species	birds, reptiles, mammals	nymphs, adults	blood-sucking	bacterial
Dermanyssidae (sucking mites)	5 genera, 37 species	birds, mammals	nymphs, adults	blood-sucking	viral, bacterial
Halarachnidae (lung/ear mites)	7 genera, 10 species	mammals	nymphs, adults	mucosal erosion	-
Raillietiidae (ear mites)	1 genus, 7 species	mammals	nymphs, adults	ear wax	-
Rhinonyssidae (nasal mites)	30 genera, 160 species	birds	nymphs, adults	inflammation	-
Varroidae (bee mites)	1 genus, 5 species	bees	nymphs, adults	haemolymph-feeding	viral
Superorder: Acariformes (diverse group of mites, without posterior stigmata) [351 families, 32,000 species]					
Order: Prostigmata [Trombidiformes, Actinedida] (sucking mites, stigmata on gnathosoma) [121 families, 17,000 species]					
Demodecidae (follicle mites)	7 genera, 65 species	mammals	larvae, nymphs, adults	inflammation	-
Cheyletidae (fur mites)	80 genera, 500 species	mammals (dogs, cats, rabbits), birds	larvae, nymphs, adults	pruritus	-
Myobiidae (fur mites)	46 genera, 185 species	mammals (rodents, bats, marsupials)	larvae, nymphs, adults	mange	-
Psorergatidae (itch mites)	3 genera, 77 species	mammals (rodents, artiodactyls)	larvae, nymphs, adults	mange	-
Trombiculidae (chigger mites)	71 genera, 3,000 species	mammals, birds	larvae	skin-feeding	bacterial
Order: Astigmata [Sarcoptiformes, Acaridida] (fur/feather/itch/dust mites, lacking stigmata) [230 families, 15,000 species]					
Sarcoptidae (itch mites)	3 genera, 42 spp./ssp.	mammals	larvae, nymphs, adults	scabies, mange	-
Psoroptidae (scab mites)	20 genera, species	mammals (carnivores, ungulates)	larvae, nymphs, adults	mange	-
Listrophoridae (fur mites)	20 genera, 170 species	mammals (esp. rodents)	larvae, nymphs, adults	mange	-
Myocoptidae (fur mites)	10 genera, 70 species	mammals (esp. rodents)	larvae, nymphs, adults	myocoptic mange	-
Cytoditidae (airsac/nasal mites)	2 genera, 12 species	birds	larvae, nymphs, adults	respiratory signs	-
Knemidokoptidae (burrowing mites)	7 genera, 16 species	birds	larvae, nymphs, adults	scaly face, scaly leg	-
Laminosioptidae (quill/skin mites)	8 genera, 25 species	birds	larvae, nymphs, adults	flesh/skin lesions	-

The superorder Acariformes comprises acarines without posterior respiratory stigmata and includes two major orders of parasites: trombidiform mites (order Prostigmata) with stigmata on the gnathosoma (capitulum) or propodosoma; and sarcoptiform mites (order Astigmata) which lack stigmata and peritremes and respire through their cuticles. Over 16,000 species of astigmate mites have been described in 230 families: with around 12,000 species in 154 families being free-living or predatory in terrestrial or aquatic environments (including a large assemblage of soil-dwelling oribatid mites); and some 4,000 species in 76 families occurring as commensals or parasites of arthropods and vertebrates (notably birds and mammals). Parasitic species may be ectoparasitic (on external surfaces of the host) or endoparasitic (within host epidermal or respiratory tissues) and their development often only includes 2 nymphal stages (in contrast to 3 nymphal stages in free-living species, sometimes including a specialized heteromorphic deutonymph (hypopus) adapted for phoretic dispersal or tolerance of adverse conditions). Common names for many of the parasitic groups include mange, itch, or scab mites as they may cause serious inflammatory skin conditions in their hosts.

Adult mites tend to be small, slow moving, whitish stages with soft cuticles and round-oval bodies (never vermiform) often with long setae. They possess chelate or dentate chelicerae, unbarbed hypostomes, small inconspicuous palps, legs with coxae fused to the body wall and tarsal segments bearing complex pulvilli (pad-like or trumpet-like) and empodia (claw-like or sucker-like, but never bearing tenet hairs). Most parasitic species may complete their entire life-cycles on individual hosts, so horizontal transmission between hosts is primarily by physical contact. A total of 10 astigmate superfamilies have been recognized (Acaroidea, Analgoidea, Canestrinioidea, Freyanoidea, Glycyphagoidea, Hemisarcoptoidea, Histiostomatoidea, Hypoderatoidea, Pterolichoidea, Sarcoptoidea) and an additional 2 families are currently unplaced (Cytoditidae, Heteropsoridae).

Early classification schemes identified different assemblages principally on the basis of host and site specificity; including bird-associated feather mites (e.g. Analgoidea); bird-associated skin mites (e.g. Knemidokoptidae), mammal-associated fur mites (e.g. Listrophoridae), mammal-associated skin mites (e.g. Psoroptidae); and mammal-associated skin-burrowing mites (e.g. Sarcoptoidea). However, phylogenetic studies (both cladistic and molecular) have revealed that many groups are not monophyletic but para- or poly-phyletic, so further studies are required to resolve the fidelity of most groups. Recently, molecular studies suggested that 16 sarcoptoidean families may belong to 2 main lineages: 13 families identified in a 'sarcoptid' complex (Atopomelidae, Audycoptidae, Chirodiscidae, Chirorhynchobiidae, Galagalgidae, Gastronyssidae, Lemurnyssidae, Listrophoridae, Listropsoralgidae, Myocoptidae, Pneumocoptidae, Rhyncoptidae, Sarcoptidae), and 3 families in a 'psoroptid' complex (Lobalgidae, Paracoroptidae, Psoroptidae). Nevertheless, most families can still be categorized into 4 broad 'morphoecotypes': namely; fur mites (Atopomelidae, Chirodiscidae, Listrophoridae, Lobalgidae), skin mites (Chirorhynchobiidae, Myocoptidae, Psoroptidae), skin-burrowing and follicle mites (Rhyncoptidae, Sarcoptidae), and respiratory mites (Gastronyssidae, Lemurnyssidae, Pneumocoptidae). The family Myocoptidae comprises small elongate mites whose palps and legs are modified to grasp hairs in the fur of their hosts. Ten 10 genera have been recognized as ectoparasites on small mammals; namely, *Apocalypsis, Criniscansor*, *Dromicioptes, Dromiciocoptes*, *Gliricoptes*, *Histiophorus, Myocoptes*, *Sciurocoptes*, *Trichobius,* and *Trichoecius*. Members of the genus *Myocoptes* have oval bodies with 2 anterior pairs of legs bearing short-stalked pretarsi with flap-like heart-shaped pulvilli, and 2 posterior pairs of legs equipped with large hook-like pincers for clasping hairs. Some 34 species have been described from rodents (murids, cricetids, nesomyids), 11 species have been assigned to the subgenus *M.* (*Myocoptes*), 3 species to the subgenus *M.* (*Comyoptes*), while the remaining species are unplaced. The species *M. musculinus* causes myocoptic mange in mice, characterized by pruritic dermatitis and alopecia.

***Myocoptes* species**	**Hosts**	**Location**	**Clinical signs**	**Distribution**
Subgenus *M.* (*Myocoptes*)				
M. M. dendromus	Rodentia: nesomyid (gray climbing mouse, Brants' climbing mouse, chesnut climbing mouse)			Africa
M. M. gerbillicola	Rodentia: murid (Kemp's gerbil, Congo gerbil)			Africa
M. M. grammomys	Rodentia: murid (woodland thicket rat, common rufous-nosed rat)			Africa
M. M. hybomys	Rodentia: murid (Peter's striped mouse)			Africa
M. M. ictonyx	Carnivora: mustelid (striped polecat)			Africa
M. M. kivuensis	Rodentia: murid (African marsh rat), geomyid (Botta's pocket gopher)			Africa
M. M. malacomys	Rodentia: murid (Edward's swamp rat, big-eared swamp rat)			Africa
M. M. nudus	Rodentia: murid (yellow-spotted brush-furred rat, Nyika rock rat)			Africa
M. M. spinulatus	Rodentia: nesomyid (gray climbing mouse, Brants's climbing mouse)			Africa
M. M. hoogstraali	Rodentia: murid (lesser Egyptian gerbil)			Egypt
M. M. neotomae	Rodentia: cricetid (eastern woodrat)			North America
Subgenus *M.* (*Comyoptes*)				
M. C. nesokia	Rodentia: murid (short-tailed bandicoot rat)			Asia
M. C. striatus	Rodentia: nesomyid (South African pouched mouse, Pousargues's African fat mouse)			Africa
M. C. verrucosus	Rodentia: murid (gerbil)			Africa
Unplaced				
M. brevipes	Rodentia: cricetid (Gunther's vole)			Europe
M. canadensis	Rodentia: cricetid (lemming)			North America
M. glareoli	Rodentia: cricetid (bank vole)			Europe
M. glirinus	Rodentia: glirid (European edible dormouse)			Europe
M. hintoni	Rodentia: sciurid (red squirrel)			Europe
M. jamesoni	Rodentia: cricetid (eastern meadow vole)			North America

M. japonensis (incl. subspp. *japonensis*, *canadensis*)	Rodentia: cricetid (grey red-backed vole, southern red-backed vole, Smith's vole, bank vole, common vole, short-tailed field vole, European water vole, European snow vole, European pine vole, tatra pine vole, eastern meadow vole, tundra vole, singing vole, northern collared lemming), sciurid (groundhog)			Eurasia, North America
M. kalrai	Rodentia: muris (lesser Egyptian gerbil)			Egypt
M. lepidotus	Rodentia: murid (red rock rat)			Africa
M. lophuromys	Rodentia: murid (Woosnam's brush-furred rat)			Africa
M. meriones	Rodentia: murid (Tamarisk jird, Libyan jird)			Asia
M. musculinus	Rodentia: murid (house mouse, wood mouse, yellow-necked mouse, spinifex hopping mouse), cricetid (white-footed mouse), caviid (guinea pig); Dasyuromorphia: dasyurid (tiger quoll)	fur	myocoptic mange, pruritus, inflammation, scales, crusts, alopecia	worldwide
M. ondatrae	Rodentia: cricetid (muskrat)			Europe
M. persicus	Rodentia: cricetid (grey dwarf hamster)			Middle-East
M. pitymys	Rodentia: cricetid (woodland vole)			North America
M. queenslandicus	Rodentia: murid (black-footed tree rat)			Australia
M. rattus	Rodentia: murid (brown rat)			Africa
M. romboutsi	Rodentia: murid (house mouse)			Europe
M. squamosus	Rodentia: cricetid (tundra vole, eastern meadow vole)			Europe, North America
M. tenax	Rodentia: cricetid (short-tailed field vole)			Europe

Parasite morphology: *Myocoptes* spp. produce 4 different types of morphological stages during their developmental cycles: eggs; larvae; nymphs (2 instars); and adult mites. The eggs are pale opaque prolate ellipsoidal stages measuring around 200 x 80 μm and are glued onto hairs by one pole such that they lay along the hair shaft. Larvae are squat oval stages measuring from 180-280 μm in length. They are hexapod, bearing 3 pairs of ventral legs, the first 2 anterior pairs ending in flap-like pulvilli and the third midbody pair terminating in pincer-like hooks for grasping hairs. Nymphs are slightly larger measuring from 250-350 μm in length and 2 sequential instars are thought to occur (protonymphs followed by deutonymphs, sometimes called tritonymphs). All nymphs are octopod, bearing 4 pairs of legs, having developed another pair posterior to the ventral midbody which end in conspicuous pincer-like hooks. Adult mites have irregular oval bodies that are elongated ventrally and dorsoventrally flattened. They range in size from 160-380 x 93-135 μm and have chitinized cuticles that are lightly tanned. Adults have 2 main tagma: a small anterior gnathosoma (head); and a large posterior idiosoma (body). The gnathosoma is triangulate with a truncated tip bearing well-developed mouthparts modified for grasping hairs. The mouthparts consist of a pair of long stylet-like chelicerae with terminal chelae flanked by small sensory palps without claws (apoteles). The mouth has a dorsal rostrum and a ventral unbarbed hypostome. The alimentary tract consists of a tubular foregut (oesophagus, pharynx), saccular midgut (ventriculus with caeca) and a short tubular hindgut (with excretory Malpighian tubules) terminating in a postero-ventral anus. The idiosoma has a distinct dorsal plate with numerous scale-like striations while the ventral surface is ornamented with many small spine-like denticles. The body has 4 distinct pairs of dorsal setae and a pair of long caudal setae, but lacks respiratory stigmata. The ventral idiosoma gives rise to 4 pairs of stout legs which are heavily chitinized and often darker brown in colour. Most legs have 6 segments (coxa, trochanter, femur, genu, tibia, and tarsus), except for the fourth pair in males which have 5 segments (fused tibia-tarsi). All legs have coxae fused to anteroventral body wall and the 2 anterior pairs of legs end in short-stalked pretarsi with large flap-like (heart-shaped) pulvilli, while the 2 posterior pairs are equipped with large hook-like pincers for clasping hairs (the tibia and tarsi fold against the inner striated surface of the genu and femur). Adult mites display considerable sexual dimorphism, with males being smaller than females (160-210 x 93-135 cf. 265-380 x 110-130 μm), their bodies having less pronounced striations, their posterior margins being bilobed, and their fourth pair of legs enlarged to grasp females during copulation. Adult males have 2 testes with tubular vas deferens leading to an ejaculatory duct and long sheathed aedeagus (penis) opening to a deltoid ventral genital opening. Adult females have 2 ovaries with tubular oviducts leading to a globular uterus (with shell glands) and vagina (with accessory organs for sperm reception (bursa copulatrix) and storage (spermathecae)) opening to a ventral slit-like genital opening.

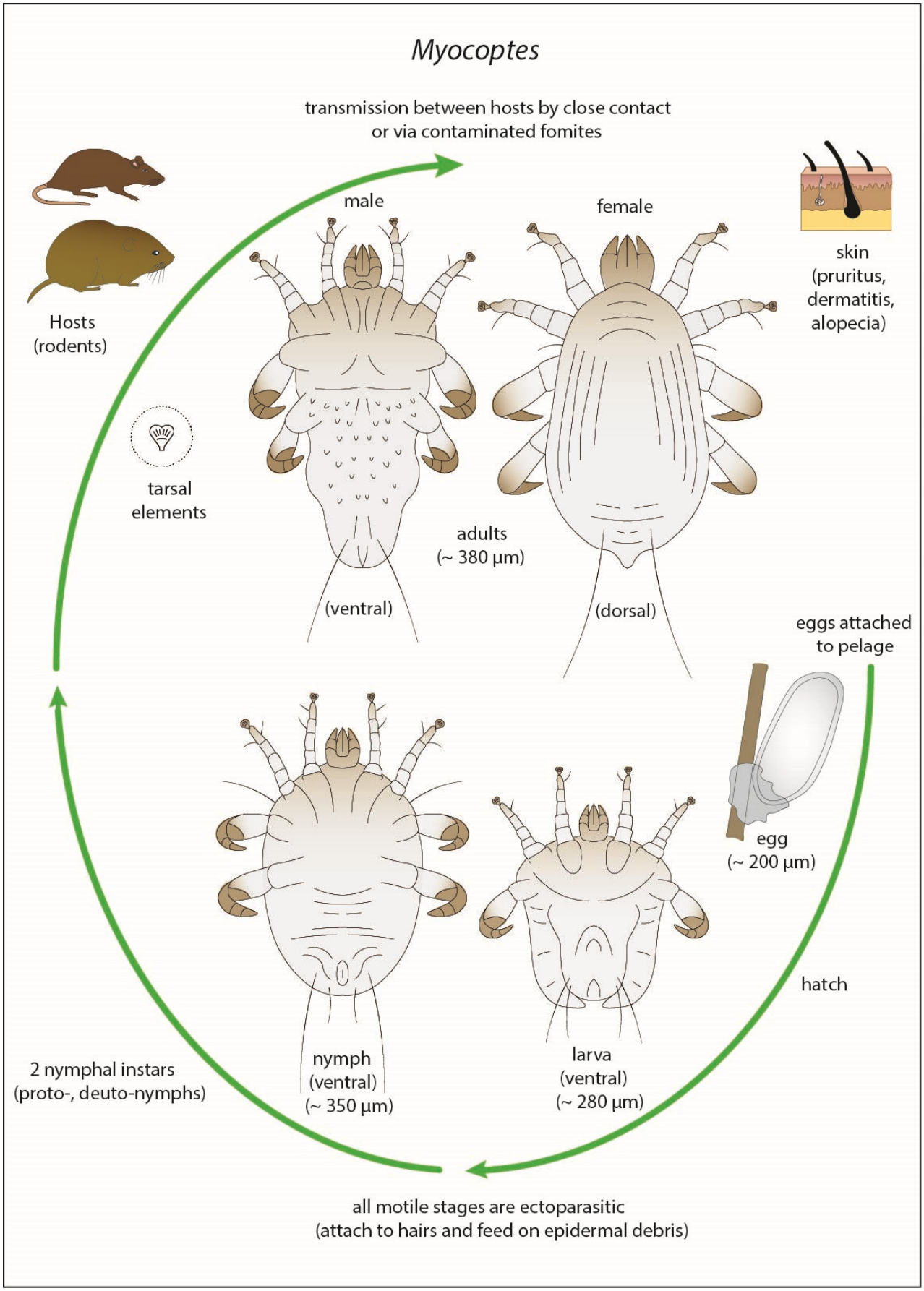
Site of infection: These mites are surface-dwellers and live in the pelage (fur) mostly of rodents. Some 34 species have been described from 6 rodent families, including caviids (guinea pigs), cricetids (voles, woodrats, hamsters, lemmings, muskrats, mice), geomyids (pocket gophers), glirids (dormice), murids (rats, gerbils, mice, jirds), nesomyids (climbing mice, pouched mice) and sciurids (squirrels, groundhogs), as well as from dasyurid marsupials (tiger quolls) and mustelid carnivores (striped polecats). Mites are frequently found on hair shafts, and sometimes on the skin surface, particularly over the flanks and rumps of their hosts, but sometimes extending over the entire dorsum in heavy infestations.

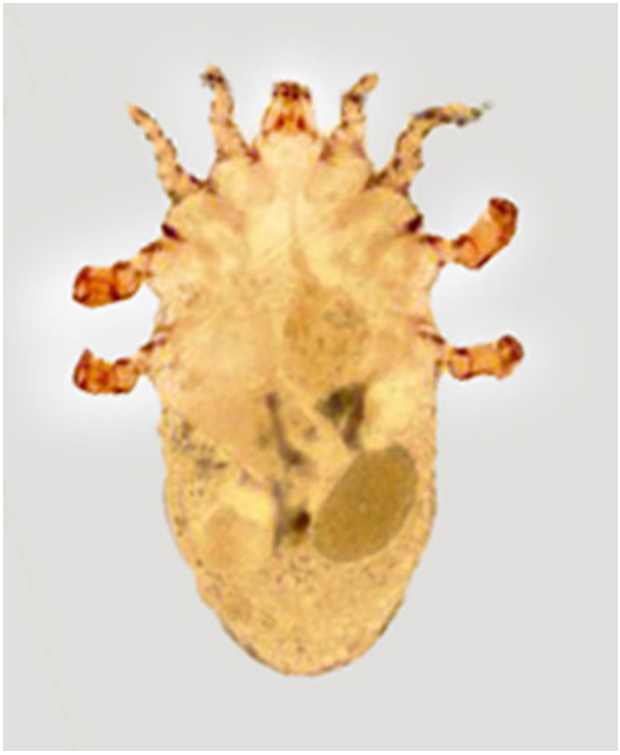
Pathogenesis: Infestations can be quite widespread and abundant in rodent hosts, but are often benign and of little clinical significance. Heavy infestations, however, can cause pruritic dermatitis (myocoptic mange), particularly in stressed, ill or immuno-compromised animals living in confined crowded situations (including laboratory colonies). These fur mites clasp to hairs and do not burrow into the skin. They feed on superficial epidermal material (hair/skin scales, cellular debris) at base of hairs, and their presence has been found to be less immunologically sensitizing than other mite infestations (such as *Myobia* spp.). Infestations may cause inflammation, erythema and pruritus leading to biting-stress, scratching and alopecia. Signs may remain mild, including ruffled fur and patchy hair loss, or become more severe, with generalized alopecia, ulcerations and self-mutilation. In some mouse strains (especially those genetically manipulated to be immunodeficient), infestations may progress to cause epidermal excoriation, ulcerative dermatitis, hypersensitivity dermatitis and pyoderma. Infestations may occur in rodents of all ages, and neonates as young as 5 days old may be infested as soon as they grow fur.

Developmental cycle and mode of transmission: *Myocoptes* spp. undergo gradual/incomplete (hemimetabolous) metamorphosis whereby eggs hatch larvae that moult through nymphal stages to form adult mites. All developmental stages may occur on the same individual host and transmission occurs through direct contact with infested hosts or infested fomites. Gravid female mites glue their eggs one at a time onto hair shafts (more distally on the hair than those deposited by Myobia spp.). The eggs hatch within 5 days releasing hexapod larvae which attach to hairs and feed on epidermal debris for several days before moulting to first-stage nymphs (protonymphs). These stages attach to hairs and feed for a short period before moulting to second-stage nymphs (deutonymphs, sometimes called tritonymphs). These final nymphal stages attach to hairs and feed for several days before undergoing their final moult to form adult mites (either males or females). Adult stages mate on their hosts and fertilized female mites begin oviposition. The whole life-cycle may be completed in as little as 14 days, but little is known about the longevity or fecundity of mites. Adult stages have been shown to abandon dead rodents as the carcase cools, but their survival characteristics off-host are unknown. Transmission is through direct animal to animal contact (especially in crowded cages/nests, when animals huddle together for security or warmth, during maternal suckling of young, or even contact with infested carcases) or via contact with infested fomites (such as cages, litter, bedding containing viable mites displaced from hosts).

Differential diagnosis: The diagnosis of infestations on rodents is difficult due to the asymptomatic nature of most infestations, the small size of the mites and their cryptic locations within pelts. Even when clinical signs of mange become apparent, they are nonspecific (dermatitis, alopecia) and may be attributed to many potential causes (such as other ectoparasites, bacterial and fungal infections, and even allergies and hypersensitivities). Infestations are diagnosed by the direct microscopic detection of mites and mite eggs on hosts or in samples collected by vacuum aspiration, hair plucks (trichograms), or by sticky tape impressions (applied against the grain of fur). Mites can be readily identified microscopically by their unique morphological characteristics. Skin scrapings have sometimes been used but they are not ideal for detecting non-burrowing mites living on hairs on the skin surface. Infestations can be detected at post-mortem by placing carcases or pelts in bags or dishes to collect mites as they leave cooling samples. More recently, molecular biological techniques have been used to detect infestations in faecal samples, skin swabs or cage swabs by the polymerase chain reaction (PCR) amplification of specific nuclear (18S and 28S ribosomal RNA) or mitochondrial (cytochrome b, cytochrome c oxidase subunit 2, ATP synthase F0 subunit 6) gene sequences.

Treatment and control: Infestations in laboratory animal colonies and pet stores have been successfully treated with topical acaricides (dusts, sprays, baths) or systemic acaricides (oral, injectable, pour-ons), including arsenic and sulphur mixtures, carbamates (carbaryl), organochlorines (dieldrin, chlorfenethol, benzene hexachloride), organophosphates (chlorpyrifos, dichlorvos) and macrocyclic lactones (ivermectin, selamectin, eprinomectin). Repeated treatments are often required as most chemicals are not strongly ovicidal and will not kill eggs. Various preventive measures have been used in animal production and holding facilities to contain the spread of mites, including regular health surveillance (monitoring to presage treatment, isolation and quarantine), enhanced sanitation (cleaning cages/pens, regularly changing litter/bedding, treating animal houses with acaricidal sprays/dusts with long residual activity) and promoting biosecurity (maintaining barrier containment in specific-pathogen-free colonies, excluding wildlife/vermin).


Myocoptes
transmission between hosts by close contact
or via contaminated fomites
Hosts
(rodents)
male
female
skin
(pruritus,
dermatitis,
alopecia)
tarsal
elements
adults
(~ 380 µm)
(ventral)
(dorsal)
eggs attached
to pelage
egg
(~ 200 µm)
hatch
nymph
(ventral)
(~ 350 µm)
larva
(ventral)
(~ 280 µm)
2 nymphal instars
(proto-, deuto-nymphs)
all motile stages are ectoparasitic
(attach to hairs and feed on epidermal debris)



Myocoptes adult

Myocoptes egg