Chorioptes
(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). Psoroptids are non-burrowing mites with oval bodies and the last two pairs of legs project beyond the body margin. Infestations by *Chorioptes bovis* may cause allergic exudative dermatitis (chorioptic mange) in domestic animals.

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:	Psoroptidae (non-burrowing mites, oval bodies, third and fourth pairs of legs project beyond body margin)
Genus:	*Chorioptes* (parasitic on skin of horses/sheep/cattle)
Species:	*C. bovis* causes mange in domestic animals

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 Psoroptidae contains non-burrowing skin mites with oval bodies and 4 pairs of legs projecting well beyond the body margin. They are obligate mammalian ectoparasites commonly known as scab mites as their feeding activity causes dermatitis resulting in scab formation at the bite site. A total of 17 genera have been identified (*Acaroptes*, *Caparinia*, *Cheiroalalges*, *Choriopsoroptes*, *Chorioptes*, *Choriotodectes*, *Echimyalges*, *Hyracoptes*, *Listropsoralges*, *Listropsoralgoides*, *Myoproctalges*, *Nasalialges*, *Otodectes*, *Paracoroptes*, *Petauralges*, *Psorochorioptes*, and *Psoroptes*). The genus *Chorioptes* is characterized by oval non-burrowing mites with rounded styliform mouthparts and distinctive leg structures (with all 4 pairs of legs bearing short-stalked pretarsi bearing cup-shaped sucker-like pulvilli, except for the third pair of legs in females which lack ambulacra but bear 2 long setae). A range of *Chorioptes* spp. were originally described from different mammals on the basis of their presumed host specificity, but subsequent biological studies found that many *Chorioptes* spp. were able to interbreed (and thus may be the same species). Recent molecular characterization studies have also shown many isolates belong to 2 clades, most referable to *C. bovis* and some to *C. texanus*. Further studies are required to resolve species differentiation for isolates from both domesticated and wild animals. At present, 7 species are considered valid in ungulates and carnivores around the world. Several species have gained notoriety as the aetiological agents of an allergic exudative dermatitis (known as chorioptic mange or barn itch) particularly in cattle, horses and sometimes sheep, goats and camelids.

***Chorioptes* species**	**Hosts**	**Location**	**Clinical signs**	**Distribution**
C. bovis (syn. *C. caprae, cuniculi, equi, ovis*)	Artiodactyla: bovid (cattle, sheep, goat), camelid (llama); Perissodactyla: equid (horse); Lagomorpha: leporid (rabbit)	skin (esp. legs)	mange, irritation, pruritus, scabs, scales, crusts	worldwide
C. crewei	Artiodactyla: bovid (red-flanked duiker)		mange	Africa
C. japonensis	Artiodactyla: bovid (Japanese serow)			Japan
C. mydaus	Carnivora: mephitid (Sunda stink-badger)			South-East Asia
C. panda	Carnivora: ursid (giant panda, Asian black bear)			Asia
C. sweatmani	Artiodactyla: cervid (moose)			Europe
C. texanus	Artiodactyla: bovid (goat, cattle, Taiwan serow), cervid (moose, European elk, reindeer, fallow deer)	skin	mange, irritation, pruritus	worldwide

Parasite morphology: *Chorioptes* spp. form 4 different types of morphological stages during their development: eggs; larvae; nymphs; and adults. The eggs are ovoid white-grey transparent stages measuring around 160 x 80-90 µm. They are embryonated when laid and attached to the host skin with a sticky substance. Larvae have ovoid somewhat flattened bodies measuring around 150-200 µm long with well-developed anterior mouthparts and 3 pairs of ventral legs. The first 2 pairs of legs are well-developed, segmented, anteriorly directed and terminate in cup-shaped suckers. The third pair of legs are smaller, posteriorly directed and terminate in long setae. Nymphs are larger in size than larvae and have developed a fourth pair of legs (albeit short and slender) located posteriorly. Two nymphal instars are formed, both showing increasing sexual dimorphism with respect to body size, leg structure and developing genitalia. First nymphal instars are known as protonymphs. Females measure around 200 µm long, their first 2 pairs of legs are well-developed, the third pair have long setae, the fourth pair are small with short setae, and the hind end of the body has a developing gonopore (birthing tract). Males measure around 150 µm long and are similar in morphology to larvae but are larger and have a fourth pair of short legs. The second nymphal instars are known as deutonymphs. Females measure around 250

μm long and are similar to protonymphs but the hindlegs have longer setae and the gonopore is clearly visible as a transverse subterminal slit. Males measure around 200 μm long and have smaller hindlegs as well as 2 developing posterior protuberances. Adult mites have oval dorsoventrally-flattened bodies that measure from 300-600 μm in length and are covered with a finely striated cuticle. The have 2 distinct tagma: a small anterior gnathosoma (head) and larger posterior idiosoma (body). The gnathosoma is short, rounded and bears styliform chewing mouthparts comprising a pair of 3-segmented chelicerae with terminal stylet-like chelae flanked by a pair of small sensory 2-segmented palps (without a terminal claw or apotele). The oral opening (mouth) has a dorsal rostrum, ventral buccal cone and unbarbed hypostome. The alimentary tract consists of a tubular foregut (oesophagus, pharynx), saccular midgut (ventriculus with caeca), tubular hindgut (with excretory Malpighian tubules) leading to subterminal anus. The idiosoma has inconspicuous anterior and posterior dorsal shields with several setae but no spines. Respiratory stigmata and tracheae are absent as the mites respire through their cuticles. The ventral surface gives rise to 4 pairs of legs divided into 2 anterior pairs projecting forwards well beyond the body margin and 2 posterior pairs projecting backwards (the fourth pair being small and often not projecting beyond the body margin). The legs consist of 6 segments (coxa, trochanter, femur, genu, tibia, tarsus) with the coxae fused to the body wall and coxae 1 and 2 well separated from coxae 3 and 4. All legs (except the third pair on females) terminate in short pretarsi with unsegmented stalks or pedicels (not jointed like *Psoroptes*) ending in cup-shaped suckers (rather than trumpet-shaped pulvilli like *Psoroptes*). The third pair of legs on both females and males each have 2 long whip-like setae, and short curved tarsal claws are also present on the first 3 pairs of legs in males, and the first 2 pairs in females. In addition to differences in leg structures, adult mites exhibit considerable sexual dimorphism with males being smaller than females and having a bi-lobed posterior end rather than a rounded end like females. Male mites range in length from 300-450 μm and possess a pair of adanal copulatory suckers each having 5 distinctive setae (2 broad and 3 hair-like). The posterior end of the body is deeply incised medially with foliate setae (whereas the posterior end of *Otodectes* males is only slightly excavated medially with simple setae). Males have 2 testes with tubular vas deferens leading to the ejaculatory duct and a long sheathed aedeagus (penis) opening through the genital pore. Female mites range in length from 400-600 μm and have a subterminal genital opening (gonopore or ovipore) which appears as a transverse slit with a pair of trailing apodemes. Females have 2 ovaries with tubular oviducts connecting to a common uterus (with muscular shell-glands) and a saccular vagina (with accessory organs (bursa copulatrix, spermathecae) for sperm receipt and storage).

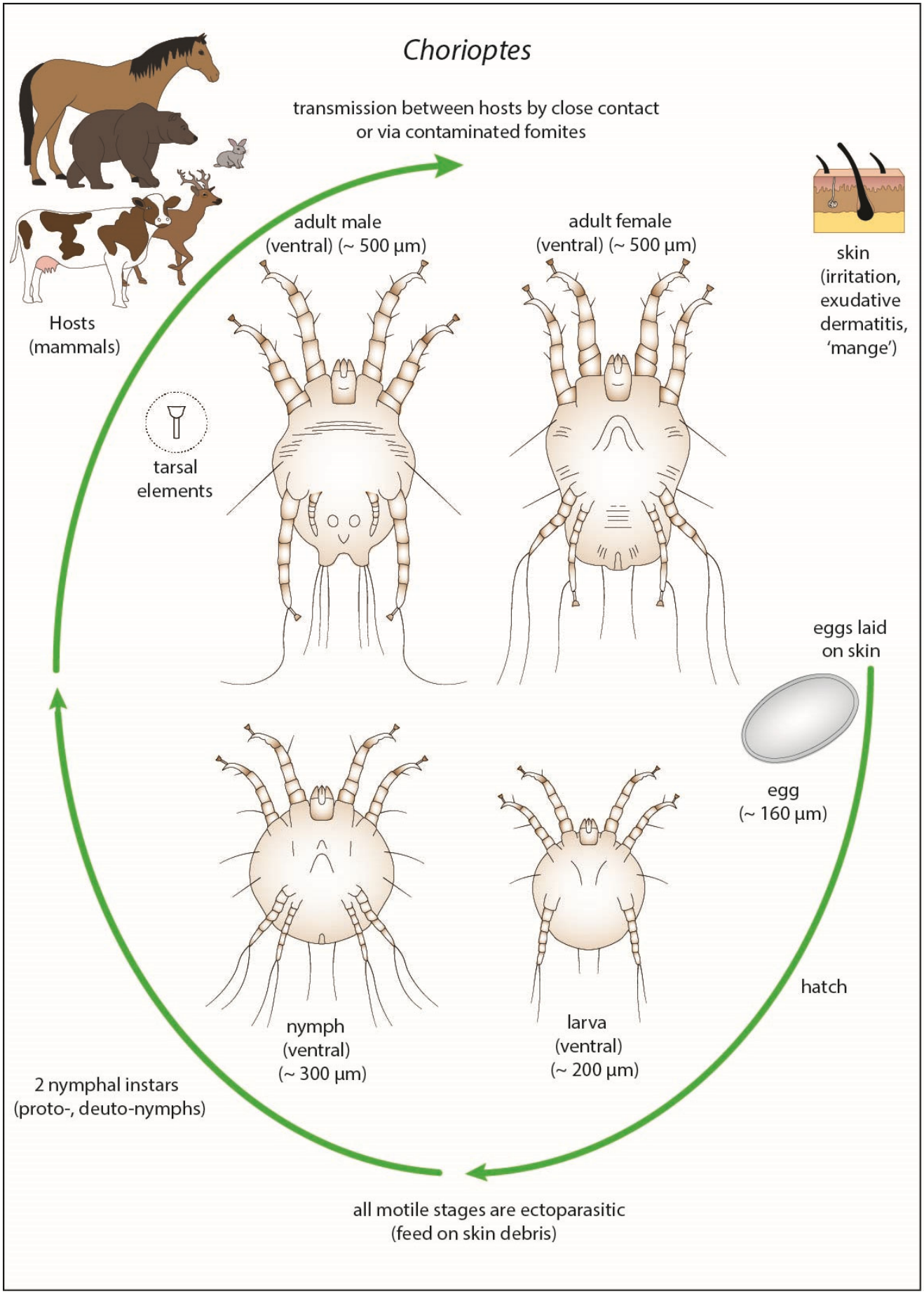
Site of infection: *Chorioptes* are non-burrowing mites living on the surface of the skin, mainly on herbivores. Many species were originally described on the basis of host occurrence, but genetic and molecular characterization studies have reconciled most into some 7 species found on domestic and semi-domestic ungulates (bovids, camelids, cervids equids), lagomorphs (rabbits) and some carnivores (mephitids, ursids). Infestations exhibit considerable site specificity with most found on lower portions of the host, especially the feet and legs, but sometimes also extending to the udders/scrotum, base of the tail, perineum, and occasionally the ears.

Pathogenesis: Many infestations remain asymptomatic, even to the extent that some texts refer to these surface-dwelling mites as ecto-commensals as they feed on skin debris rather than on the living skin itself. However, infestations on certain hosts can cause a clinical disease (known variously as chorioptic mange, barn itch, leg mange, foot mange, tail mange, scrotal mange and symbiotic scab) mostly on cattle and horses and sometimes on sheep, goats and camelids. The disease is relatively mild, less pruritic and more localized than psoroptic or sarcoptic mange, and is characterized by an allergic exudative dermatitis which dries to form crusts. Heavily infested animals may experience alopecia (hair loss) and moderate loss of production. All motile developmental stages use their chewing mouthparts to feed on epidermal debris on the skin surface, but they may cause local irritation exacerbated by the release of mite antigens (saliva and faeces) causing the host to scratch and abrade the skin surface. This may produce small skin lesions, typically tiny blisters with serum or tissue fluid seeping from the wound. As mites multiply, these blisters may fuse locally and rupture with the contents desiccating to form crusts or scabs (roughly 3 mm in diameter). In cattle, infestations usually involve the legs or base of the tail, but may spread to other regions. Clinical signs include skin irritation, inflammation, erythema, pruritus, papules, restlessness, self-trauma, ulceration, exudates, crusts, scabs, scaling and alopecia. Infestations may worsen when animals are crowded or confined leading to production losses (reduced weight gains and decreased milk production). In horses, mites are usually confined to the legs below the knees, but may extend to the belly, axilla and groin. Clinical signs include inflammation, oedema, erythema, pruritus, skin lesions with serous exudates which dry to form crusts, and sometimes ulceration with scab formation. Animals may stamp, paw or kick their feet and rub the hind pastern on hard objects. Draft horses with feathered fetlocks may develop chronic pastern dermatitis progressing to lichenification and excessive skin folds forming verruciform lesions. In severe cases, exudative dermatitis in the pastern region can spread to carpal and tarsal joints. Infestations in sheep usually involve the lower hind legs and ventral abdomen but they are generally light and frequently overlooked even when papules and crusts occur. However, heavy infestations in the scrotum of rams may cause exudative dermatitis with yellowish crusty lesions (scrotal mange) which may lead to a rise in scrotal temperature and temporary infertility (reversible following elimination of mites). Chorioptic mange is primarily a winter disease as mite numbers increase during the cooler winter months. However, mites often persist at low numbers over warmer summer months in the absence of clinical disease.

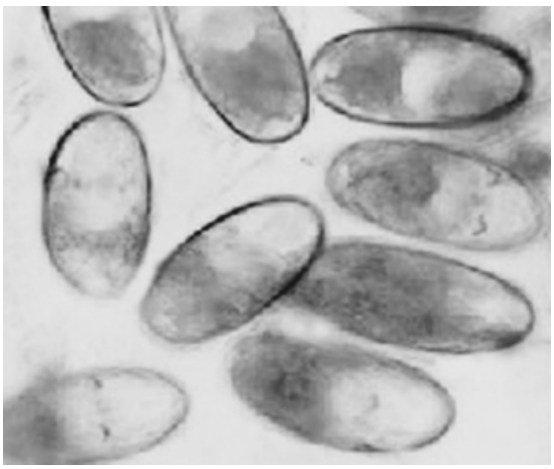
Developmental cycle and mode of transmission: *Chorioptes* spp. undergo gradual (hemimetabolous) metamorphosis in that eggs hatch hexapod larvae that moult to octopod nymphs and then adult mites. The whole life-cycle may be completed on the same host, and transmission between host occurs via direct contact or contaminated fomites. Gravid female mites oviposit eggs onto the skin of the host, cementing 14-20 eggs/female on the skin surface or on flakes of the scurf. The eggs hatch in around 4 days to release 6-legged larvae which feed for 3-5 days before resting for a day prior to moulting to nymphs. The first nymphal instar (protonymphs) also feed for 3-5 days before resting for a day before moulting into the second nymphal instars (deutonymphs). This developmental stage feeds for 7-8 days before resting for a day prior to moulting into adult mites. Adults commence feeding and seek mates with males inseminating females. Adult mites live for 2-7 weeks, and fertilized females lay 1-2 eggs per day. The whole life-cycle may be completed in 10-21 days but often takes longer in cooler conditions. The primary mode of transmission between animals is through direct physical contact allowing the mites to transfer between hosts, particularly on farms where animals are kept in close proximity for extended periods. However, mites can live off hosts for several weeks so some transmission occurs via the contamination of fomites (pens, stalls, bedding, grooming equipment, etc).

Differential diagnosis: While infestations may be indicated on clinical grounds (exudative dermatitis), they should be confirmed and differentiated from other possible causative agents, including other mites (such as *Psoroptes* and *Sarcoptes*) as well as bacteria, fungi and some allergic reactions. Confirmation of diagnosis is best achieved by direct detection of mites, mite eggs or mite faeces (scybala) in skin scrapings taken at the edges of lesions or in crusts/scabs. Samples are usually subject to caustic digestion in potassium hydroxide solutions to break down host material (mite cuticles are resistant to digestion) and mites can then be identified microscopically by their unique morphological features. Skin biopsies have also been used to diagnose infections but they have shown low sensitivity. Molecular biological techniques have been used to detect and characterize infestations following the polymerase chain reaction (PCR) amplification of nuclear (ribosomal DNA, internal transcribed spacer regions) gene sequences. Molecular studies have also been used to examine the allergenic properties of mite proteins by transcriptome analyses of isolated RNA followed by bioinformatic comparisons with sequences lodged in the mite allergen database. Preliminary results suggest that some cross-reactivity may occur with allergens from house dust mites (*Dermatophagoides*).

Treatment and control: Most infestations are self-limiting and do not progress to clinical disease. However, when chorioptic mange becomes evident, infestations respond well to treatment with topical or systemic chemical acaricides, including traditional chemicals (such as lime sulphur), organophosphates (coumaphos, phosmet, crotoxyphos, malathion, methoxychlor, trichlorfon), pyrethroids (permethrin), amidines (amitraz) and macrocyclic lactones (ivermectin, doramectin, moxidectin, eprinomectin). Repeated treatments are often required after 7-10 days as relapses or re-infestations are common. Attention should be paid to any drug contra-indications and with-holding periods as some drugs have toxic side-effects or persist within host tissues for some time. Various preventive measures should also be adopted to break transmission cycles by regularly monitoring livestock, isolating infested animals, placing new livestock into temporary quarantine, cleaning animal holding facilities and grooming equipment, treating the immediate environment with acaricides with long-lasting residual activity, and reducing animal contact with wildlife using barriers or traps.


Chorioptes
transmission between hosts by close contact
or via contaminated fomites
Hosts
(mammals)
adult male
(ventral) (~ 500 µm)
adult female
(ventral) (~ 500 µm)
skin
(irritation,
exudative
dermatitis,
'mange')
tarsal
elements
eggs laid
on skin
egg
(~ 160 µm)
hatch
nymph
(ventral)
(~ 300 µm)
larva
(ventral)
(~ 200 µm)
2 nymphal instars
(proto-, deuto-nymphs)
all motile stages are ectoparasitic
(feed on skin debris)

Chorioptes adult



Chorioptes eggs