Trixacarus
(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). Sarcoptids are burrowing mites with circular bodies and the last two pairs of legs do not project beyond the body margin. Infestations by *Trixacarus caviae* occur in the skin of guinea pigs and may cause dermatitis (mange).

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:	Sarcoptidae (burrowing mites, circular bodies, third and fourth legs do not project beyond body margin)
Genus:	*Trixacarus* (parasitic on skin of guinea pigs)
Species:	*T. caviae* causes mange in guinea pigs

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 Sarcoptidae comprises the burrowing mites that invade the skin of mammalian hosts causing intense pruritus. These 'itch mites' have soft circular bodies and 4 pairs of legs, the posterior 2 pairs not projecting beyond the body margin. Numerous genera have been recognized and allocated to 3 subfamilies (Caenolestocoptinae, Diabolicoptinae, Sarcoptinae). although another 5 genera remain unplaced (*Chirophagoides*, *Grammolichus*, *Lophuromyopus*, *Rodentopus*, *Sclerolichus*). The subfamily Sarcoptinae contains 15 genera (*Chirnyssoides*, *Chirobia*, *Cynopterocoptes*, *Kutzerocoptes*, *Mysarcoptes*, *Notoedres*, *Nycteridocoptes*, *Prosarcoptes*, *Prosopodectes*, *Rousettocoptes*, *Sarcoptes*, *Satanicoptes*, *Teinocoptes*, *Trixacarus*, *Tychosarcoptes*). The genus *Trixacarus* (syn. *Caviacoptes*) is characterized by small oval mites with short stubby legs lacking claws, dorsal striations interrupted by many pointed scales, and a dorsal anus. Three species have been described as ectoparasites on rodents, with the species *T. caviae* recognized as a common cause of mange (dermatitis and alopecia) in guinea pigs around the world.

***Trixacarus* species**	**Hosts**	**Location**	**Clinical signs**	**Distribution**
T. caviae (guinea pig mite, Sellnick mite)	Rodentia: caviid (guinea pig)	skin (body)	irritation, inflammation, pruritus, alopecia	worldwide
T. diversus	Rodentia: murid (brown rat, black rat, house mouse), cricetid (hamster, Drylands vesper mouse)			Europe
T. eliurus	Rodentia: nesomyid (dormouse tufted-tailed rat)			Madagascar

Parasite morphology: *Trixacarus* spp. form 4 different types of morphological stages during their developmental cycles: namely, eggs, larvae, nymphs and adults. Eggs are ovoid transparent stages ranging in size from 115-165 x 70-110 μm. They hatch to release larvae which have oval slightly-flattened bodies measuring 110-160 x 70-120 μm. They have striated cuticles adorned with small spines. They possess 3 pairs of short legs, the 2 anterior pairs ending in stalked suckers and the posterior pair terminating in long setae. Larvae moult to form nymphs, which have 4 pairs of legs (having developed another posterior pair). Two nymphal instars are formed: protonymphs measuring 120-175 x 85-135 μm; and deutonymphs (sometimes called tritonymphs) measuring 150-200 x 110-160 μm. The final nymphal stages moult to form oval-circular adult mites with discoidal (ventrally-flattened) bodies measuring 120-240 x 85-180 μm. Adults have 2 tagma: a small anterior gnathosoma (head) and a large posterior idiosoma (body). The gnathosoma bears cutting-sucking mouthparts comprising a pair of segmented chelicerae terminating in claw-like chelae flanked by a pair of small 2-segmented sensory palps without terminal apoteles. The oral opening (mouth) has a dorsal rostrum, ventral buccal cone and unbarbed hypostome. The alimentary tract comprises a tubular foregut (oesophagus, pharynx), saccular midgut (ventriculus with caeca) and a tubular hindgut (with excretory Malpighian tubules) opening to a dorsal anus (located more posteriorly in males than females). The idiosoma bears a small precapsular shield (like *Sarcoptes*) and the cuticle bears fine striations which are interrupted dorsally by numerous scales which are more sharply-pointed than those of *Sarcoptes* (unlike *Notoedres* which only has a few rounded scales). The idiosomal setae are setose, while those of *Sarcoptes* are spine-like and those of *Notoedres* are rod-like. *Trixacarus* adults also have at least 2 pairs of genital setae (like *Sarcoptes*, but unlike *Notoedres* which has only one pair at most). Like all members of the Astigmata, *Trixacarus* mites lack respiratory stigmata and tracheae (they respire through their cuticles). The ventral idiosoma bears 4 pairs of short stubby legs, with 2 pairs projecting anteriorly beyond the body margin, and 2 pairs projecting posteriorly but not extending beyond the body. The legs have 6 segments (coxa, trochanter, femur, genu, tibia, and tarsus) with the coxae fused and sunk into body wall contributing to their short-legged appearance. The tarsi have small terminal hooks (not claws) and the 2 pairs of anterior legs terminate in long pretarsal stalks bearing cup-shaped suckers, while

the 2 pairs of posterior legs end in long setae. Adult mites display sexual dimorphism with females being larger than males (160-240 x 120-180 μm cf. 120-150 x 85-100 μm). Male mites have 2 testes with tubular vas deferens leading to the ejaculatory duct and long sheathed aedeagus (penis) opening to the subterminal ventral genital pore. Female mites have 2 ovaries with tubular oviducts leading to the globular uterus (with shell-glands) and vagina (with accessory organs (bursa copulatrix and spermathecae) for sperm receipt and storage). The female genital opening appears as a subterminal ventral transverse slit paralleling the cuticular body striations.

Site of infection: These burrowing mites are obligate ectoparasites in the skin of various rodents, usually infesting the back and flanks but sometimes extending over the shoulders and neck. Three species have been reported from caviid, cricetid, murid and nesomyid rodents around the world, with the species *T. caviae* recognized as a common cause of mange in guinea pigs.

Pathogenesis: Infestations are often progressive, initially causing mild dermatitis (mange) that worsens over time leading to excoriations, lichenification, alopecia, sometimes seizures and death. The mites burrow under the skin provoking inflammatory changes involving the 4 cardinal signs of rubor (redness), calor (heat), tumor (swelling) and dolor (pain), probably exacerbated by allergic/hypersensitive reactions to mite antigens (surface proteins, saliva and faeces). Hosts experience considerable irritation with intense pruritus and skin lesions progressing from erythematous papules to exudative vesicles that dry to form yellow scales and crusts. The skin exhibits orthokeratotic hyperkeratosis, marked acanthosis, lichenification and alopecia, occasionally forming eosinophilic microabscesses and necrotic areas. Animals undertake vigorous self-grooming, often inflicting severe self-trauma and excoriations through their frantic biting, scratching and rubbing. Open skin lesions are highly prone to secondary bacterial infections which may become pustular. Persistent infestations may kill the host after 3-4 months, with death being attributed to severe dehydration (from expanding sores) and starvation (from failure to eat due to extreme pain and discomfort). In severe infestations, animals may also experience seizures (often induced during handling) which resolve following successful mite treatment (not requiring anti-convulsant medication). Chronic infestations may also affect reproduction performance, with abortion and foetal resorption seen in pregnant animals. Infestations are most severe in young and aged animals, those subject to stress and poor environmental conditions, and those with concomitant disease (including hypovitaminosis C). Infestations may remain subclinical for several months (even years), but become problematic when guinea pigs reproduce or are subject to illness or stress. In several instances, a nonclinical carrier state has been mooted when clinical outbreaks have occurred in animals or colonies long isolated from other animals. These mange mites are not zoonotic, but on rare occasions they may cause temporary pruritic papulovesicular skin lesions in some people even though mites cannot live or reproduce on humans

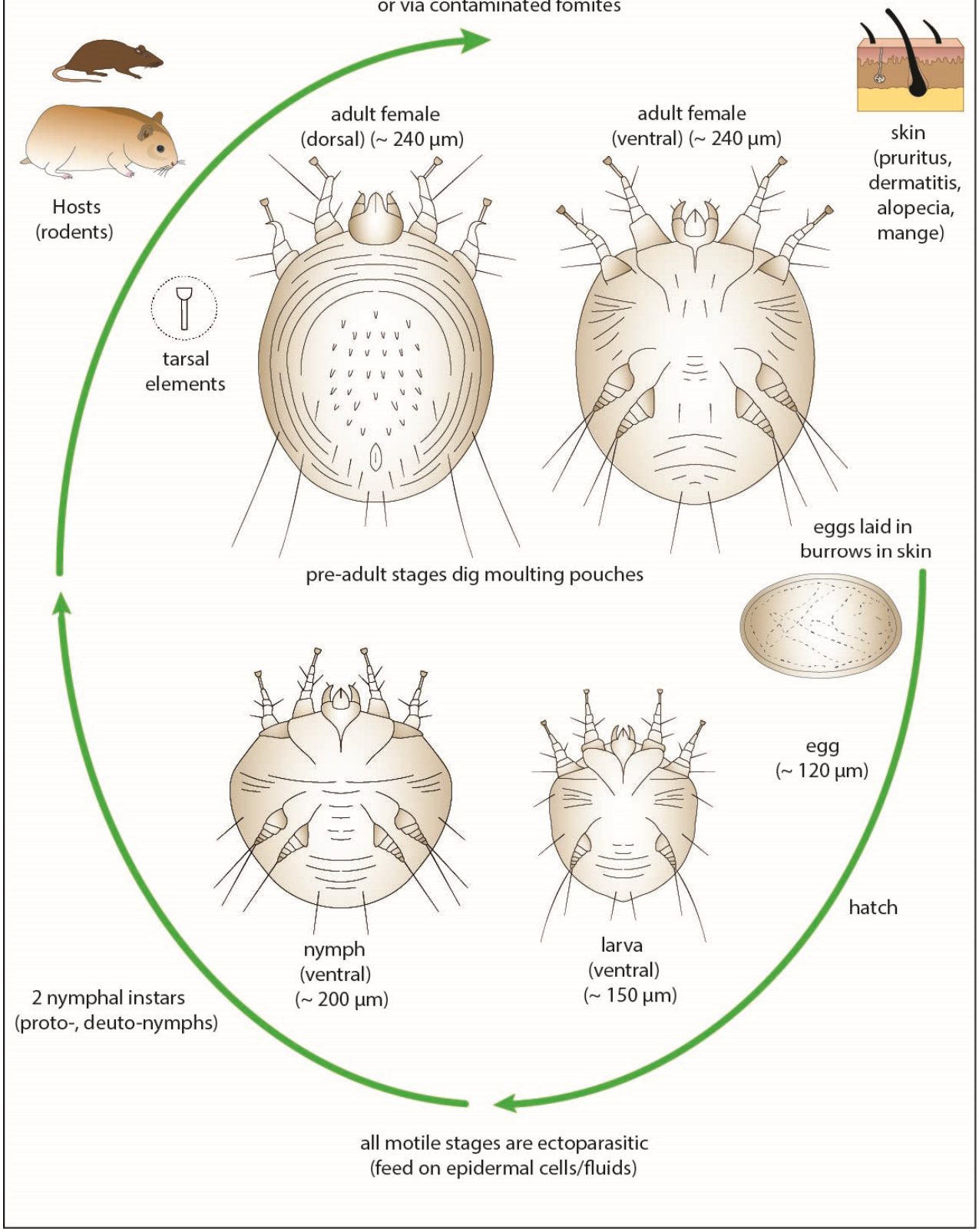
Developmental cycle and mode of transmission: *Trixacarus* spp. undergo hemimetabolous (gradual or incomplete) metamorphosis where eggs hatch larvae which moult to nymphs and then adult mites. All stages in the life-cycle may occur on the same host, and transmission to other hosts occurs by direct contact or via contaminated fomites. Adult female mites oviposit eggs in their burrows which hatch in 4-5 days to release hexapod larvae. The larvae move onto the skin surface and dig their own shallow burrows (called moulting pouches). They feed for several days before moulting into the first nymphal instar (called protonymphs). The protonymphs move onto the skin surface and excavate their own shallow moulting pouches. They feed for several days before moulting to form the second nymphal instar (known as deutonymphs, but sometimes called tritonymphs in early literature). These nymphs migrate onto the skin surface and dig shallow moulting pouches before forming adult mites. Male mites leave their pouches to seek mates, while female mites remain in place. Mating occurs when an adult male penetrates the moulting pouch of an adult female. Impregnated females then expand their moulting pouches into deeper burrows, laying eggs as they go. The whole life-cycle may be completed in 14-21 days. Transmission occurs primarily through direct contact with infested animals, particularly through close contact between mother and offspring. Mites seldom leave their hosts unless dislodged onto bedding or as a result of overpopulation or the death of the host. All developmental stages can survive for several weeks off hosts, so some transmission must occur via contaminated fomites, such as animal holding facilities and bedding.

Differential diagnosis: Infestations may be suspected on the basis of symptomatology (dermatitis, crusting and alopecia) but other aetiological agents may cause similar clinical signs. Differential diagnosis is made by the microscopic examination of deep skin scrapings. Mites are often found at the edges of lesions as well as in skin flakes and crusts. Samples are usually subject to caustic digestion in potassium hydroxide to break down skin cells and debris, while mites remain unscathed as their cuticles are impervious to digestion. Occasionally, infestations have been detected by the histopathological examination of skin biopsies which reveal mites, mite fragments or eggs in the stratum corneum. Changes in clinical haematological and biochemical parameters are relatively nonspecific and include leukocytosis, monocytosis, eosinophilia and basophilia (consistent with cellular inflammation) as well as hypoglycaemia and low levels of serum albumin and globulin (consistent with protein loss).

Treatment and control: Clinical infestations respond well to treatment with chemical acaricides, with early topical treatments with sulphur compounds, organochlorines (lindane), organophosphates (malathion, coumaphos) and pyrethroids (permethrin) now largely superseded by systemic treatments with arylpyrazoles (fipronil) and macrocyclic lactones (ivermectin, selamectin, doramectin). Nonetheless, most drugs are not ovicidal and do not kill eggs, so repeated or protracted treatments are required to eliminate newly-

emergent stages. Drug efficacy is also improved if animals are bathed beforehand with antiseborrheic shampoos to remove crusts and debris. Careful attention should be paid to any drug contra-indications, as some macrocyclic lactones are not well absorbed by guinea pigs and several commonly used diluents (such as propylene glycol) may cause dermal inflammation or necrosis. Control programs designed to prevent the spread of infestations are based around animal management (regular monitoring and treatment of cohorts, isolation and quarantine, hygienic husbandry), environmental sanitation (cleaning animal housing and bedding, fomite decontamination), and wildlife exclusion (vermin control using barriers, traps or baits).

Trixacarus


transmission between hosts by close contact
or via contaminated fomites
Hosts
(rodents)
skin
(pruritus,
dermatitis,
alopecia,
mange)
adult female
(dorsal) (~ 240 µm)
adult female
(ventral) (~ 240 µm)
tarsal
elements
eggs laid in
burrows in skin
pre-adult stages dig moulting pouches
egg
(~ 120 µm)
hatch
nymph
(ventral)
(~ 200 µm)
larva
(ventral)
(~ 150 µm)
2 nymphal instars
(proto-, deuto-nymphs)
all motile stages are ectoparasitic
(feed on epidermal cells/fluids)

Trixacarus adult

Trixacarus egg