Acariasis

Mange and Other Mite Infestations

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Importance

A large number of mite species infest animals. Most inhabit the skin, feathers or mucous membranes, although a few are endoparasites. Many mites are tolerated without consequences unless their populations become very large; other species regularly cause pruritus, mild to severe dermatitis, and hair or feather loss (mites found on the integument), or respiratory signs (air sac mites). Mites such as *Sarcoptes scabiei* (sarcoptic mange) and *Psoroptes ovi*s (psoroptic mange) can cause significant economic losses in livestock from debilitation and damage to the hides and wool. Secondary bacterial infections and mortality can occur in severe mite infestations, notably during infestation with *S. scabiei* and other members of the Sarcoptidae. Sarcoptic mange is also a concern in threatened or fragmented wildlife populations; some populations have experienced severe declines in their numbers after these mites were introduced. Avian mites such as *Ornithonyssus sylviarum*, *Orn, bursa*, *Dermanyssus gallinae*, *Knemidokoptes* spp. and *Sternostoma tracheacolum* can cause disease in poultry or pet birds. Mites also affect laboratory and pet rodents, rabbits, exotic animals and reptiles.

Humans occasionally become infested with zoonotic mites, which can cause discomfort and dermatitis. A few species can transmit diseases, such as human vesicular rickettsiosis. Mites from animals do not usually survive for very long on humans, and most zoonotic infestations are self-limiting.

Etiology

Acariasis in animals is caused by a variety of mites (class Arachnida, subclass Acari). Due to the great number and ecological diversity of the Acari, as well as the lack of fossil records, the higher level classification of these organisms is still in flux. In addition, the validity of some species names is still uncertain.

Mites are extremely abundant and diverse; approximately 50,000 species have been described. Sixteen families contain about 50 mites that may affect livestock, poultry, pets and laboratory animals. Additional families and species of mites are found on wild and exotic animals. Most mites live on or in the skin, feathers or mucous membranes, but a few species are endoparasites. Some mites do not cause any apparent ill effects unless their population becomes unusually large. Other species, such as *Sarcoptes scabiei*, can result in clinical signs even when only a few mites are present.

The mites described below are mainly those that cause clinical signs in domesticated animals. Their zoonotic potential is described where information is available; however, this information is likely to be incomplete. Human sarcoptic mange (*S. scabiei* var *hominis*) is also discussed, as it is closely related to, and must be differentiated from, zoonotic *S. scabiei* infestations.

Family Atopomelidae

Chirodiscoides caviae (the guinea pig fur mite) affects guinea pigs. Its zoonotic potential is considered to be low.

Family Cheyletiellidae

The Cheyletiellidae contains approximately 15 genera, which affect mammals and birds. *Cheyletiella yasguri*, *C. blakei* and *C. parasitovorax* are the most prevalent species on domesticated animals, and usually affect dogs, cats and rabbits. *Cheyletiella* spp. are not very host specific, and can be transmitted to humans. However, they do not appear to reproduce on human skin; thus, human infestations are self-limiting.

Family Demodecidae

Among the Demodecidae, *Demodex* is the only genus important in domesticated animals. *Demodex* mites are very host specific, and transmission between species, including zoonotic transmission, is very unlikely.

Family Dermanyssidae

Mites in this family primarily parasitize rodents and birds. The host specificity of these mites is usually relatively low, and some will also feed on humans or other

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animals. *Dermanyssus gallinae* (chicken mite, red mite, roost mite, poultry mite) is a parasite of birds that can cause dermatitis in people. *D. americanus* (American bird mite) and *D. hirundinis* have been reported to affect humans, but cases are uncommon. *Liponyssoides sanguineus*, a parasite of small rodents, is also zoonotic.

Family Knemidokoptidae

Mites in the family Knemidokoptidae affect birds. Species that affect poultry, hobby birds or pet birds include *Knemidokoptes mutans, K. pilae, Picicnemidocoptes laevis, Neocnemidocoptes columbicola, N. columbigallinae, N. gallinae* and *Procnemidocoptes janssensi*. Additional species affect wild birds. Mites in this family do not seem to be transmitted readily to species other than their usual host(s).

Family Listrophoridae

The Listrophoridae mainly infest rodents, but *Lepoacarus gibbus* can cause mange in domesticated rabbits, and *Lynxacarus radovskyi* affects domesticated and wild cats. Humans can be affected by *Lepoacarus gibbus*; however, the mites do not seem to feed readily on people and such infestations are rare.

Family Macronyssidae

Mites in this family feed on birds, mammals and reptiles. The host specificity of these mites is usually relatively low. Several mites from this family are known to be zoonotic. They include *Ornithonyssus bacoti* (the tropical rat mite), which affects rodents and small marsupials; as well as *Orn. bursa* (tropical fowl mite) and *Orn. sylviarum* (Northern fowl mite), which normally feed on birds. Humans can also become infested with the snake mite *Ophionyssus natricis* and with *Chiroptonyssus robustipes*, a mite that normally infests bats.

Family Myobiidae

The Myobiidae occur on mammals, especially bats. Infestations are usually of little consequence on wild animals, but mite populations can cause myobiic mange in laboratory or pet rodents. *Myobia musculi* and *Radfordia affinis* affect mice, while *Radfordia ensifera* occurs on rats.

Family Myocoptidae

The Myocoptidae affect rodents, insectivores and marsupials. *Myocoptes musculinus* is common, but typically asymptomatic, on laboratory mice. Other mites in this family may also occur on mice, but are not known to be important pathogens.

Family Psorergatidae

The two important genera for domesticated animals are *Psorobia* and *Psorergates*. Most of the parasites in this family affect rodents and bats.

Family Psoroptidae

Mites in the family Psoroptidae affect domesticated animals, but are rarely transmitted to people. The three diseases of importance to domesticated species are psoroptic mange, chorioptic mange and infestation with ear mites.

Psoroptic mange is caused by *Psoroptes ovis*. At one time, *Psoroptes* mites were divided into several host-specific species (*P. ovis, P. equi, P. cervinus, P. cuniculi* and *P. natalensis*); however, these mites were later recognized to be members of a single species. Transmission of *P. ovis* mites between host species is nevertheless thought to be rare and require close contact. Most sources do not consider this mite to be zoonotic, but one report from Egypt described infestations in 0.6% of the human population examined.

Chorioptes bovis and *C. texanus* cause chorioptic mange ('barn itch') in many species of ungulates. A number of additional *Chorioptes* species have been proposed; however, their validity (with the possible exception of a species collected from the outer ear canals of moose) is questionable. *Chorioptes* mites can be readily transmitted between different species of animals. They are not known to be zoonotic.

The ear mite *Otodectes cynotis* affects domesticated and wild carnivores. Rare, self-limiting human infestations with this organism have been reported.

Family Sarcoptidae

Several mites among the Sarcoptidae are important in domesticated animals, wild animals or people. *Sarcoptes scabie*i causes sarcoptic mange (scabies) in humans and more than 100 additional species of mammals and marsupials. More than 15 varieties of this organism have been described. They include *S. scabiei* var *hominis* in people; *S. scabiei* var. *canis, S. scabiei* var *suis, S. scabiei* var. *equi, S. scabiei* var *bovis, S. scabiei* var *ovis, S. scabiei* var *caprae* and *Sarcoptes scabiei* var *aucheniae* in domesticated animals; and additional varieties such as *Sarcoptes scabiei* var *vulpes* and *Sarcoptes scabiei* var *wombati* in exotic animals or wildlife. *Notoedres cati* causes notoedric mange ("feline scabies") in domesticated and wild cats. *Notoedres muris, N. musculi* and *N. pseudomuris* can infest laboratory rodents. *Trixacarus caviae* mainly affects guinea pigs.

Within *S. scabiei*, the degree of host specificity seems to vary with the variety of mite and the specific host. Some mites do not appear to reproduce on the aberrant host, and the infestation is self-limiting (e.g., infestation of humans by zoonotic varieties of *S. scabiei*). Other species can successfully reproduce in large numbers. For example, mite populations can be high on some cats infested with *S. scabiei* var *canis*, and on wombats with *Sarcoptes scabiei* var *vulpes*. *S. scabiei* var *hominis*, which is maintained in human populations, is the only mite that can cause persistent infections in people. However, humans can be infested transiently by the scabies mites of a wide variety of domesticated and exotic animals, as well as by *Notoedres cati.* and *Trixacarus caviae*.

Family Syringophilidae (quill mites)

The Syringophilidae are very host-specific mites, which infest birds. They live in the quill shafts and feed on fluids from the feather follicles. Some species can cause dermatitis and feather loss in birds.

Family Trombiculidae (chiggers, harvest mites)

The approximately 700 species of trombiculid mites are free-living as nymphs and adults, but parasitic as larvae. Some species can affect birds, mammals or reptiles, as well as humans. Genera known to infest humans include *Eutrombicula*, *Neotrombicula*, *Leptotrombidium*, *Schoengastia*, *Euschoengastia*, *Acomatacarus*, *Siseca* and *Blankaartia*. The host specificity of chiggers is usually relatively low.

Feather mites

Feather mites include thousands of species from 36 mite families in three superfamilies (Analgoidea, Freyanoidea and Pterolichoidea). They live on or in the feathers or skin of birds, usually without causing clinical signs.

Mites of the respiratory tract, subcutaneous tissues and other locations

Mites from several families inhabit various parts of the respiratory tract in birds and mammals. Many of these mites seem to cause little or no pathology; however, the canary mite *Sternostoma tracheacolum* (family Rhinonyssidae), which infests passerine and psittacine birds, can cause illness and even death. Most mites of the genus *Sternostoma* are fairly host specific, and occur on only one to several hosts.

Some mites live in the subcutaneous tissues (e.g., on the surface of the muscles or in fatty tissue) of birds or mammals during part of their life cycle. These mites absorb nutrients through the skin, and have not been shown to cause disease. Mites also occur in other locations, such as the cloaca of reptiles.

Food storage and house dust mites

Food storage and house dust mites or their feces can cause allergic reactions and pruritus in humans. Pyemotid mites ("itch mites") ordinarily parasitize insects that infest stored grains, hay and straw, but they can also affect people, especially if their normal hosts are destroyed. These mites are not discussed further in this outline.

Geographic Distribution

Some mites, such as *Notoedres cati*, *Otodectes cynotis*, *Cheyletiella* spp., *Chorioptes* spp., *Dermanyssus gallinae*, *Ornithonyssus bacoti* and chiggers are cosmopolitan. However, even widely distributed mites may be absent from some regions. For example, *Ornithonyssus bacoti* is not found in very cold areas such as the Arctic. Similarly, *Sarcoptes scabiei* occurs worldwide, but some variants, such as *S. scabiei* var *equi*, may be rare or nonexistent in some countries. The prevalent species of chiggers vary with the geographic region. Some mites have been reported from more limited areas, although this may not represent their entire geographic range. *Liponyssoides sanguineus* has been detected in Asia, Europe, the U.S. and northern Africa. *Chiroptonyssus robustipes* is known to occur in Central America and the southern U.S. *Chirodiscoides caviae* has been documented mainly in Asia and Europe, although it is thought to be cosmopolitan. *Ornithonyssus bursa* is widespread, and has been found in both tropical and temperate regions, while *Orn. sylviarum* occurs in temperate climates.

A few mites have been eradicated from domesticated animals in some countries. For example, *Psoroptes ovis* has been eliminated from sheep in the U.S.

Transmission and Life Cycle

Female mites lay their eggs either on the host or in the environment. The egg hatches into a larva, which generally passes through two nymphal stages to become an adult. Mites are typically transmitted between hosts by direct contact. The importance of fomites in transmission varies with the species of mite and its survival in the environment. Some mites can also be transferred between hosts by attaching to other arthropods.

Mites that are found on animals may feed on a variety of substances including tissue fluid, blood, keratin, cells, skin and feather lipids and debris, algae, fungi and other mites. Depending on the species of mite, they may live in or on the skin, feathers, subcutaneous tissues, and mucous membranes including the respiratory tract. Some mites that infest the skin, such as the Sarcoptidae and Knemidokoptidae, can tunnel into the skin and live within these burrows. Others (non-burrowing mites) live on the skin surface, fur and other sites. Some mites (e.g., *Dermanyssus* spp.) spend most of their time in the environment, and occur on animals only when feeding.

Atopomelidae

Chirodiscoides caviae is a non-burrowing mite of guinea pigs that feeds on scales from the hair shaft.

Cheyletiellidae

Cheyletiella spp. are non-burrowing mites that feed on keratinized skin cells and occasionally suck lymph. Their eggs are attached to the hair shafts by a web of threads. The mites usually live their entire lives on one host. However, females (and perhaps the eggs) can survive in the environment for up to 10 days, and fomites are also important in transmission. Nymphs, larvae and adult males die in approximately two days in the environment. In addition to being spread on objects such as leashes and grooming tools, *Cheyletiella* spp. can be transmitted on larger arthropods such as fleas, lice and flies. Most human cases are associated with an infested animal in the household.

Demodecidae

Demodex mites live mainly in hair follicles, but can also be found in the sebaceous glands, Meibomian glands and epidermal pits. These mites feed on sedum, cells and epidermal debris. They are very host specific, and are transmitted by very close contact. Transmission is probably from the dam to the neonate. *Demodex* spp. are killed quickly by desiccation (45-60 minutes at 20ºC and 40% humidity), and thus are unlikely to survive off the host for more than a few hours. Even when maintained artificially in the laboratory, *Demodex canis* lost its ability to infect the hair follicles, although it could be kept alive for up to 37 days.

Dermanyssidae

The Dermanyssidae are non-burrowing mites. *Dermanyssus* spp. are all nocturnal feeders. *Dermanyssus gallinae* adults and nymphs feed on birds' blood and tissue fluids at night (especially on the breast and lower legs), drop off the host after feeding, and hide in nearby cracks and crevices during the day. The eggs are laid in the environment, and the larvae do not feed. *D. gallinae* adults can survive in the environment for up to 34 weeks without feeding.

The life cycle of *Liponyssoides sanguineus* is similar to that of *D. gallinae*. This mite feeds on blood, usually for 1-2 hours, every few days. The adults can survive in the environment for up to two months. Humans are more likely to be bitten when the normal hosts of these mites (e.g., mice) have been eradicated.

Knemidokoptidae

Knemidocoptid mites, which affect birds, burrow in the stratum corneum of the skin. (In severe cases, *K. mutans* has been reported to invade the stratum spongiosum and stratum compactum.) The entire life cycle takes place on the bird. In some areas such as the legs, beak, mouth and cere, the resulting inflammation, hyperplasia and hyperkeratosis cause the formation of scaly encrustations, warty lesions and ribbon-like skin proliferations. *Knemidokoptes mutans* mainly affects the feet and legs of birds, while *K. pilae* causes lesions on the beak, cere and mouth of budgerigars. *Picicnemidocoptes laevis, Neocnemidocoptes columbicola* and *N. columbigallinae* occur on feathered areas of the body, and cause pruritus and dermatitis.

Close contact appears to be important in facilitating transmission. Transmission to species other than the usual host(s) appears to be rare or nonexistent. In one study, mites were transmitted between red-winged blackbirds sharing a cage, but nine other species in the same cage were unaffected. *In vitro*, *K. mutans* has been reported to survive for 4 to 9 days at 4-25ºC.

Listrophoridae

Lynxacarus radovskyi (cat fur mite) is a non-burrowing mite. This mite is not highly contagious. In one case, it was reported to affect only one cat out of a group of fourteen.

Macronyssidae

The Macronyssidae are non-burrowing mites. The zoonotic species can survive for a period of time in the environment, and can be transmitted on fomites.

Ornithonyssus sylviarum spends its entire life on its avian hosts. The nymphs and adults feed on blood; the larvae do not feed. The highest concentrations of mites are usually found near the vent area, but they can also occur at other body sites, especially as the number of mites increases. The life cycle is 5 to 12 days, and large populations of mites may be generated in a short time. *Orn. sylviarum* can survive for at least a week in the environment, and up to 3 to 4 weeks under optimal conditions. Fomites as well as infested birds are important in transmission.

The life cycle of *Orn. bursa* resembles that of *Orn. sylviarum*, but *Orn. bursa* lays some of its eggs in birds' nests. This species does not survive for more than 10 days in the environment. It is a common pest in the southern U.S., and can migrate into homes from abandoned nests, birdhouses or empty poultry facilities. Many cases in people have been associated with birds' nests on window ledges or air conditioning units. Infestations of homes tend to occur when the fledglings leave the nest and the mites are forced to seek new hosts.

Orn. bacoti lays its eggs in the burrows, nests and cages of rodents and small marsupials. It feeds on blood and drops off the host after each meal. *Orn. bacoti* adults may survive in the environment for up to 6-7 weeks without feeding. If their rodent hosts die, these mites can feed on other hosts including dogs, cats and humans, and may invade homes. They will also bite people who handle pets or laboratory rodents if the mite population is high.

The common snake mite *Ophionyssus natricis* resides mainly in skin crevasses on the animal. It is usually found around the eyes, nostrils and infraorbital bits, and under the scales.

Myobiidae and Myocoptidae (fur mites)

Myobia musculi, Radfordia affinis and *Radfordia ensifera* (family Myobiidae) affect rodents. The eggs of myobiid mites are usually attached to the base of the hair on the host. These mites feed on tissue fluids, but can also feed on blood from capillaries at the surface of the skin. They are readily transmitted between hosts, and may also infest cats, dogs and people.

Myocoptes musculinus (family Myocoptidae) is a non-burrowing fur mite that is common on laboratory mice.

Psorergatidae

Adult psorergatid mites feed, reproduce and lay their eggs in the hair follicles or small pits in the epidermis. The adult mites usually produce only minor irritation and damage; however, immature mites may enlarge the epidermal pits into fluid- or keratin-filled papular lesions that may rupture and result in inflammatory reactions. These mites do not usually survive in the environment for longer than a day.

Psoroptidae

Members of the family Psoroptidae are non-burrowing mites that remain on the surface of the skin. The zoonotic members of these families complete their entire life cycle on the host, but they can survive for a period of time in the environment.

Psoroptes ovis is usually transmitted between animals by contact, but it can also be acquired on fomites. All stages of this mite feed on the host. *P. ovis* mites are not readily transmitted between different host species.

Chorioptes mites are not very host specific, and can be transmitted between different species of animals. These mites tend to occur on the lower part of the body, especially the legs, but they can also be found on the perineum, udder, scrotum, tailhead, and in some cases the ears. *Chorioptes* mites can feed on epidermal debris at the surface of the skin, without necessarily damaging the live cells of the epidermis. The life cycle takes approximately 3 weeks to complete *in vitro*, but it can be longer on the host. Fomites as well as contact between animals can be important in transmission.

Otodectes cynotis feeds on epidermal debris inside the ear. It can also survive in the environment for a period of time (one source suggests several weeks).

Sarcoptidae

The Sarcoptidae are burrowing mites that live in tunnels in the skin. These mites complete their entire life cycle on the host, and do not survive for long periods in the environment.

Sarcoptes scabiei mites burrow in the stratum corneum of the skin. Female mites, which live for 1 to 2 months (*S. scabiei* var *hominis*), construct the characteristic long serpentine tunnels and deposit their eggs as they move through the skin. Hatched larvae migrate to the surface of the skin. Molting to the nymphal and adult stages takes place in short burrows called molting pouches. Males are rarely seen, and have been reported to die after they mate, although this is not accepted by all sources.

The number of mites infesting the host differs with the variant of S. scabiei and host species, and also varies between individuals. Most animals and most humans carry few mites. However, some individuals develop a form of scabies characterized by extremely large numbers of mites. Naive species exposed to a new S. scabiei variant also appear to control the mites poorly, and accumulate large mite populations. When the number of mites is small, transmission usually requires close, prolonged contact. In humans, fomites are of minor importance compared to direct contact, except from individuals with the "crusted" form, where the mite population is very high. The transmission of S. scabiei between animals is probably by direct contact or in contaminated bedding and similar fomites.

S. scabiei is very sensitive to desiccation, and does not remain infectious for long periods in the environment. Although some variants have been shown to survive outside the host, in an optimal environment, for up to 2 to 3 weeks, they may remain infective and able to burrow into the skin for much shorter periods. *S. scabiei* var *hominis* is reported to survive at room temperature (21°C) for 24 to 36 hours, if the relative humidity is 40-80%, and longer if the humidity is high or the temperature is colder. In a pigsty, *S. scabiei* var *suis* was found to survive for less than 12 days at 7-18ºC (45-64ºF) and a relative humidity of 65-75%. This organism was also reported to survive for 4 days or less at temperatures lower than 25ºC, 24 hours or less at 20-30ºC, and less than one hour at temperatures greater than 30ºC. In one study, pigs did not become infested if they were placed in pens vacated 24 hours earlier by pigs with acute scabies, but did become infested if the previous occupants had chronic hyperkeratotic scabies. Other estimates of the survival time for *S. scabiei* range from less than 24 hours to five days.

Notoedres cati is a burrowing mite with a life cycle similar to that of *Sarcoptes scabiei*. *N. cati* may live for a few days off the host. *T. caviae* is a burrowing mite of guinea pigs.

Syringophilidae (quill mites)

The Syringophilidae live in the quill shafts and feed on fluids from the feather follicles.

Trombiculidae

Chiggers are parasitic only in their larval stage. The free-living nymphs and adults live on invertebrates and decaying plant material. These mites lay their eggs on the ground or on low bushes or grass. The hatched larvae feed on the tissue juices of birds, reptiles, mammals or invertebrates, then drop to the ground to develop into nymphs. Humans and domestic animals can act as hosts for the larvae of some species. Depending on the species of mite, chiggers may remain on their hosts for a few hours to several days and up to a month.

Feather mites

Feather mites live inside the quills and on the surface of the feathers in birds, as well as in and on the skin. These mites may feed on a variety of material, including skin flakes, the hemolymph of other arthropods such as lice, tissue fluids, uropygial gland oil and other secretions.

Most feather mites are highly adapted to survival on the feathers, and cannot move well on other surfaces. Birds may become infested as fledglings, as well as during other times of close contact such as courtship, mating and communal roosting.

Respiratory mites

These mites live within various parts of the respiratory tract. Some mites inhabit the nasal cavity, while other species penetrate deeper. *Sternostoma tracheacolum* can be found in the air sacs and lungs, as well as other areas. It feeds on blood, and the entire life cycle takes place inside the respiratory tract.

Decontamination

A wide variety of insecticides and acaricides are used to eliminate mites. Washing in hot water, followed by drying in a hot dryer, is also effective for *S. scabiei* on bedding, clothing and other fomites. In addition, this organism can be killed by dry cleaning, or by sealing contaminated items in a plastic bag until the mites have died. The U.S. Centers for Disease Control (CDC) recommends a minimum of 3 days in a sealed bag for *S. scabiei* var *hominis*.

Infestations in Animals

Species Affected

Atopomelidae

Chirodiscoides caviae is found on guinea pigs

Cheyletiellidae

Cheyletiella spp. have a predilection for certain hosts, but can readily infest other species. *C. yasguri* is most often found on dogs, while *C. blakei* is the predominant species in cats. *C. parasitovorax* usually causes cheyletiellosis in rabbits, but it may also be common in cats.

Dermanyssidae

Dermanyssus gallinae infests a variety of birds including chickens, turkeys, pigeons and canaries. Mammals may be accidental hosts. *Liponyssoides sanguineus* is normally a parasite of mice and other small rodents such as gerbils.

Demodecidae

Demodex spp. are highly host specific. *Demodex canis* and *D. injai* are found on dogs, while *D. cati* and *D. gatoi* infest cats. *D. phylloides* occurs on pigs, *D. caprae* on goats, *D. ovis* on sheep, *D. caballi* on horses and *D. cuniculi* on rabbits. *D. bovis*, *D. tauri* and *D. ghanensis* can be found on cattle. *D. aurati* and *D criceti* infest guinea pigs.

Knemidokoptidae

Knemidokoptes mutans may be found on chickens, turkeys, and pheasants, while *K. pilae* affects budgerigars and passerine birds, especially canaries and European goldfinches. *Neocnemidocoptes gallinae* has been reported on chickens, geese and pheasants. *Neocnemidocoptes columbicola*, *N. columbigallinae* and *Picicnemidocoptes laevis* infest pigeons and other columbiform birds. *Procnemidocoptes janssensi* occurs on lovebirds (*Agapornis* spp.). Other species are found on wild (or captive exotic) birds.

Listrophoridae

Lepoacarus gibbus affects rabbits. *Lynxacarus radovskyi* infests domesticated and wild cats.

Macronyssidae

Ornithonyssus bursa infests birds including chickens, turkeys, ducks, pigeons, sparrows, starlings and myna birds. *Orn. sylviarum* infests chickens, turkeys and many other birds. These species will feed on mammals if birds are not available.

Orn. bacoti occurs on domesticated and wild rodents, especially the brown Norway rat (*Rattus norvegicus*) and the black roof rat (*Rattus rattus*). It also affects mice, hamsters and small marsupials, and will feed on other hosts.

Ophionyssus natricis infests snakes.

Myobiidae

Myobia musculi and *Radfordia affinis* occur on laboratory and pet mice. *Radfordia ensifera* occurs on laboratory rats, but it can also be found on mice.

Myocoptidae

Myocoptes musculinus infests mice, including laboratory mice.

Psorergatidae

Psorergates bos occurs on cattle, and *Psorobia* (formerly *Psorergates*) *ovis* affects sheep. *Psorergates simplex* is found in mice. Other species may affect laboratory primates.

Psoroptidae

Psoroptes ovis infests domesticated and wild ungulates, including sheep, cattle, horses and South American camelids, as well as rabbits.

Chorioptes spp. can be found on a wide variety of ungulates including cattle, horses, sheep, goats, llamas, reindeer, moose and other species. *Chorioptes bovis* and *C. texanus* do not seem to be strongly host specific. *C. bovis* affects cattle, horses, goats, sheep and camelids. *C. texanus* has been isolated from cattle, goats, reindeer (*Rangifer tarandi*) and European elk/moose (*Alces alces*).

Otodectes cynotis affects many species of carnivores including dogs, cats, ferrets, farmed foxes and mink, and wild animals.

Sarcoptidae

More than a hundred species of mammals and marsupials can be infested by *Sarcoptes scabiei*. Hosts include dogs, ferrets, cattle, water buffalo, sheep, goats, horses, swine, camels, llamas, alpacas and a number of wild or zoo animals including wombats, chamois and koalas. Cats are uncommonly affected by the mites of dogs or foxes. Infestations in rabbits are also infrequent. The varieties of *S. scabiei* are named after their predominant host species.

- *S. scabiei* var. *canis* causes sarcoptic mange in dogs. It can also infest other canids including foxes, wolves and coyotes.

- *S. scabiei* var. *vulpes* causes sarcoptic mange in red foxes. It can also infest other animals including Arctic foxes, lynx, pine marten and wolves.
- *S. scabiei* var. *suis* causes sarcoptic mange in pigs.
- *S. scabiei* var *bovis* causes sarcoptic mange in cattle.
- *S. scabiei* var. *equi* causes sarcoptic mange in horses.
- *S. scabiei* var *ovis* causes sarcoptic mange in sheep.
- *S. scabiei* var *caprae* causes sarcoptic mange in goats.
- *Sarcoptes scabiei* var *aucheniae* causes sarcoptic mange in South American camelids (llamas, alpacas, vicunas and guanacos).
- *Sarcoptes scabiei* var *wombati* causes sarcoptic mange in wombats (*Vombatus ursinus* and *Lasiorhinus latifrons*)

Most *Notoedres* spp. affect bats. *Notoedres cati* causes notoedric mange (feline scabies) in domesticated cats and wild cats including lynxes, cheetahs, leopards, ocelots and bobcats. Occasionally, it can affect non-Felidae, such as dogs, rabbits, foxes, pine civets, coatimundis, mongooses and raccoons. *N. muris* affects laboratory rats. It has also been found on some other rodents, including guinea pigs, as well as on marsupials and a hedgehog. *N. musculi* and *N. pseudomuris* can affect laboratory mice; however, *N. pseudomuris* is mainly found in wild mice. These two mites also infest a few other species of murid rodents.

Trixacarus caviae is found on guinea pigs. *T. diversus* is found rarely on laboratory rats.

Syringophilidae

"Quill mites" live on birds. *Syringophilus columbae* on domesticated pigeons and *S. bipectinatus* on chickens can cause dermatitis and feather loss.

Trombiculidae

Chiggers can affect many species of mammals, birds and reptiles.

Feather mites

Feather mites live on birds.

Respiratory mites

Sternostoma tracheacolum (the canary lung mite) is found on passerine and psittacine birds. Many species of respiratory mites do not seem to cause significant illness.

Incubation Period

The incubation period for *S. scabiei* var *canis* in dogs is 10 days to 8 weeks, and varies with the individual animal, the number of mites and the part of the body affected. The incubation period is generally longer the first time an animal is infested, as the allergic reaction to the mites takes time to develop. Pigs experimentally infected with *S. scabiei* var *suis* become symptomatic in 2 to 11 weeks. In newborn guinea pigs infested with *Trixacarus caviae*, pruritus may become evident within 72 hours of birth, and skin lesions within 3 to 4 weeks of birth. In mature guinea pigs, the clinical signs develop in 10 to 50 days.

Clinical Signs

Mite infestations are usually characterized by dermatitis and loss or damage to the hair and feathers. Some mites rarely or never cause clinical signs, while others become symptomatic only if their populations become large. However, some species of mites (e.g., *Sarcoptes scabiei*) can cause clinical signs even if only a few mites are present. Many of the clinical signs of mite infestation are due to an allergic reaction to the parasites.

Atopomelidae

Guinea pig fur mite

Chirodiscoides caviae can cause pruritus and alopecia on guinea pigs. It is a non-burrowing mite, and is less pathogenic than *Trixacarus caviae*.

Cheyletiellidae

Cheyletiellosis

Cheyletiellosis most often affects the back, shoulders and neck. The moving mites are barely visible in the coat. Some animals may be asymptomatic.

In cats and dogs, the typical lesion is a dry, scaly dermatitis with dandruff and a slightly oily coat. Pruritus is usually mild or moderate, but can be severe, and may be absent especially in cats. In some cases, there may also be erythematous, excoriated lesions, hair loss or generalized lesions. Cats may develop miliary dermatitis. A form characterized by multiple areas of crusting, scabs and alopecia, which resembles a dermatophyte infection, has also been described. Most clinical cases occur in puppies and kittens; adult cats and dogs are usually infested only lightly, even when they are in contact with young animals.

Rabbits infested with *Cheyletiella* spp. are often asymptomatic, but some animals have loose hair, which can be pulled out in clumps, and oily, scaly, erythematous, alopecic patches on the back and head. Dandruff is usually visible in the fur. *C. parasitovorax* can serve as a vector for the rabbit myxoma virus.

Demodecidae (Demodicosis)

Demodex spp. usually inhabit the skin without any apparent detrimental effect. Occasionally, the numbers of mites increase greatly, resulting in demodectic mange. The clinical signs can include a variety of skin lesions including papules, nodules and extensive hair loss. Severe or generalized demodicosis is uncommon, but can result in serious illness, secondary bacterial infections of the skin and even death.

In cattle, the clinical signs include papules and nodules that are most common on the neck, back, flank and withers. Ulcers and abscesses can be seen if the follicles rupture or secondary infections occur. Animals usually recover

spontaneously. Similar lesions are seen in sheep and pigs. In horses, the face, neck, shoulders and forelegs are most often affected with patchy, non-pruritic alopecia and scaling or nodules.

In dogs, demodicosis may be localized or generalized. The localized form is characterized by one or more mildly erythematous, alopecic areas, with or without pruritus, and sometimes with fine scales. This form resolves spontaneously in most dogs; however, up to 10% of cases may become generalized. Generalized demodicosis is a severe condition that is often complicated by secondary bacterial infections. Numerous alopecic areas grow and coalesce, and the skin develops folliculitis from the mites, as well as exudates, crusting and plaques from secondary pyoderma. Marked lymphadenopathy is common. Juvenile onset (< 1 year of age) generalized demodicosis can be seen in dogs in good health, but a genetic predisposition has been observed. It can resolve spontaneously in 30-50% of young dogs. Adult onset generalized demodicosis often occurs in animals with neoplasia or other serious illnesses, and it is more difficult to cure. Pododemodicosis involves only the paws, and is usually complicated by secondary bacterial infections.

Feline demodicosis is usually mild, localized and self-limiting. It is especially common around the eyes, ears and neck. Rare generalized cases have been seen, especially in cats with other diseases. The generalized form is not usually as severe in cats as dogs. The clinical signs may range from patchy thinning of the fur, or symmetrical hair loss resembling endocrine alopecia, to more severe cases with erythema, scales, papulocrustous dermatitis and secondary bacterial infections.

Demodicosis also occurs in pet and laboratory rodents, often when they are stressed, malnourished or immunosuppressed, or have other predisposing factors. The clinical signs in guinea pigs and hamsters include alopecia, pruritus, dermatitis and changes in skin pigmentation. In guinea pigs, demodicosis may be associated with chronic renal disease.

Dermanyssidae

Dermanyssus gallinae

In poultry, *D. gallinae* can result in anemia and lower productivity including decreased weight gain in young birds, reduced egg laying in hens and decreased reproductive potential in males. Restlessness, anemia, excess preening, pruritus and deaths have been reported in cage birds.

Infestations are rare in dogs and cats. The clinical signs may include erythema, papules and crusts, especially on the head, back and legs. The lesions are usually but not always intensely pruritic. Mites may sometimes be seen on the animal. They are red when engorged with blood, but white, gray or black at other times. Dermatitis associated with *D. gallinae* was also reported in a horse that was in contact with poultry. The clinical signs were severe pruritus and hair loss from rubbing, mainly on the head.

Knemidokoptidae (scaly leg, scaly face and other conditions)

Knemidokoptes mites may infest birds without clinical signs until stress or other factors result in increased mite populations.

Knemidokoptes mutans causes 'scaly leg' in chickens, turkeys, and pheasants. This condition is characterized by crusting and thickening of the skin, and may result in lameness and distortion or loss of the digits. Occasionally, the comb and wattles may be affected. The birds become anorexic, and death may result after several months.

K. pilae causes a condition called 'scaly face' in budgerigars. It is characterized by white, proliferative encrustations on the beak, cere and corners of the mouth. The legs, vent and periorbital region are occasionally affected. This organism also infests some passerine birds, and can result in crusting on the legs and surfaces of the digits, warty lesions and ribbon-like proliferations of the skin, a condition known as 'tassel foot.' Overgrowth of the toenails may also be seen, and may affect the ability of the bird to perch. Tassel foot is especially common in canaries and European goldfinches.

Neocnemidocoptes gallinae is found on the back, head, neck, abdomen and upper legs of chickens, geese pheasants and pigeons. It causes intense pruritus, feather picking, and feather loss or broken feathers. The skin may become scaly, thickened and wrinkled, especially on the neck. *Picicnemidocoptes laevis* can cause mange in pigeons and other columbiform birds.

Knemidokoptic mange can be life threatening by affecting the birds' ability to feed, perch or preen.

Listrophoridae

Lynxacarus radovskyi can cause mild, scurfy mange is in cats and wild Felidae. The coat is usually dull and dirty, and the mites attached to the fur give it a "salt and pepper" appearance. The hair is easily removed. The skin may either be normal or have a papulocrustous rash. There is usually little pruritus.

Lepoacarus (formerly Listrophorus) gibbus can cause mange that resembles cheyletiellosis in domesticated rabbits.

Macronyssidae

Ornithonyssus bursa and Orn. sylviarum

Ornithonyssus bursa and *Orn. sylviarum* can result in blackened 'dirty-looking' feathers, as well as crusts, thickening of the skin, cracks and scabs around the cloaca. Productivity may be decreased.

Ornithonyssus bacoti

In some laboratory and pet rodents, *Orn. bacoti* has been reported to cause anemia, debility, weakness, decreased reproduction and deaths from blood loss. Pruritus may be severe. One infested mouse colony used for research appeared to be completely unaffected, although human caretakers developed severe dermatitis and discomfort.

Ophionyssus natricis

The common snake mite *Ophionyssus natricis* tends to occur around the eyes, nostrils and infraorbital pits, and under the scales. The skin may appear coarsened, and the shedding cycles are often irregular and increased in frequency. Decreased vitality may be seen if the infestation is heavy. Affected reptiles may spend an unusually long time soaking in water.

Myobiidae and Myocoptidae

Infestations with fur mites (*Myobia musculi, Radfordia affinis* and *Myocoptes musculinus*) in pet or laboratory mice can be asymptomatic or limited to occasional scratching. Other cases are characterized by a pruritic, greasy dermatitis, and thinning of the hair over the head and dorsum. Self-trauma may result in ulcerations. Most mice that carry *Myocoptes musculinus* do not develop clinical signs unless they are stressed or immunocompromised. In rats, severe infestations with *Radfordia ensifera* may cause pruritus, which can be severe, and self trauma.

Psorergatidae ("itch mites")

These mites rarely cause disease in wild animals; however, psorergatic mange can be seen if mite populations become large, especially on sheep, laboratory rodents and occasionally laboratory primates.

In cattle, *Psorergates bos* can cause pruritus and mild, patchy alopecia. Intense pruritus, scaling, matting of the wool and hair loss can occur in some sheep affected by *Psorobia ovis*. Weight loss can be seen, in addition to damage to the wool. However, most sheep appear to be unaffected or mildly affected by this mite. In mice, *Psorergates simplex* typically causes small white nodules on the head and neck.

Psoroptidae

Psoroptic mange

In cattle, psoroptic mange (*Psoroptes ovis* infestation) is characterized by intense pruritus, papules and sticky yellowish crusts, as well as secondary lesions from self-trauma. The lesions usually begin on the shoulders and rump, but can spread to involve almost the entire body. Consequences can include weight loss, decreased milk production and increased susceptibility to other diseases. Infestations may be fatal in untreated calves.

Sheep with psoroptic mange develop large, yellowish, scaly, crusted lesions, mainly on the wooly areas of the body. These lesions are intensely pruritic. Anemia and emaciation may be seen in untreated animals.

The ears are mainly affected in goats; however, the mites sometimes spread to the head, neck and body.

In horses, psoroptic mange is characterized by pruritus and papules, seen mainly on the parts of the body covered by thick hair (e.g., under the mane and forelock and at the base of the tail). The lesions progress to alopecia and thick, hemorrhagic crusts. Another form is characterized by otitis externa.

In rabbits, *P. ovis* causes the accumulation of serum and brown crusts in the ear, resulting in scratching and shaking of the head. Secondary infections, weight loss, decreased production and torticollis may be sequelae.

Chorioptic mange

Chorioptes bovis, and *C. texanus* cause chorioptic mange, or 'barn itch' in ungulates including cattle, sheep, goats, horses and South American camelids. Chorioptic mange is usually relatively mild, less pruritic and more localized than sarcoptic or psoroptic mange. The mites tend to occur on the lower regions of the body, especially the feet and legs, but they can also be found in the udder/scrotum, tailhead and perineum, as well as the ears. When the mites are few in number, animals may be asymptomatic, but clinical signs develop as their numbers increase. This typically occurs when the animal is housed indoors, with the mite population diminishing when the animal is kept outside in summer. In addition to pruritus, the lesions can include papules, crusts, ulcers, exudates and alopecia, and other signs of self-trauma. The scrotum and hind legs are often involved in rams, and fertility may be affected. In horses, the clinical signs are usually chronic if left untreated, and usually wax and wane with the seasons. Many cattle are infested without clinical signs.

Otodectes cynotis (ear mites)

Otodectes cynotis mainly causes otitis externa, and is associated with thick reddish-brown crusts in the ear canals. Its activity can lead to secondary bacterial or fungal infection, or vestibular signs including torticollis. The degree of pruritus varies. Cats can sometimes tolerate moderate numbers of mites without clinical signs. Occasionally, the infestation spreads to the skin, particularly the head and neck, base of the tail and paws. On the skin, *O. cynotis* causes a pruritic dermatitis with redness, scaling and crust formation.

Syringophilidae (quill mites)

Syringophilus columbae on domesticated pigeons and *S. bipectinatus* on chickens can cause dermatitis and feather loss.

Sarcoptidae - Sarcoptic mange (Sarcoptes scabiei)

The hallmark of sarcoptic mange in most species is intense pruritus; however, some species are reported to develop crusted lesions with large numbers of mites and little pruritus. The mites prefer relatively hairless parts of the body, and the initial lesions often occur in these locations. As the alopecia spreads, the rash often becomes generalized. Severe untreated cases can be fatal; deaths are usually the result of secondary bacterial infections. Severe, difficult to control infestations have been reported in some animals such as alpacas.

Dogs

In dogs, the lesions are often found first on the ventral chest and abdomen. Other common locations are the ears, periorbital region, elbows and legs. The typical lesion is an intensely pruritic papular rash with thick yellowish crusts. Scratching and rubbing can lead to a variety of lesions, including erythema, ulcers, bleeding and hemorrhagic crusts. Peripheral lymphadenopathy can be seen and emaciation can occur in severe cases. Untreated sarcoptic mange may last for weeks to years. Secondary bacterial infections are common. Asymptomatic carriers may exist.

Scabies incognito can be seen in meticulously groomed dogs. This form is characterized by constant pruritus but few or no lesions other than mild erythema and occasional self-trauma.

Cats

In cats, rare infestations with *S. scabiei* have been described mainly as crusted parakeratotic lesions with little or no pruritus, and with large numbers of mites. Some cats had advanced lesions with thick, wrinkled, scaly skin and extensive hair loss on the head, neck, abdomen, proximal limbs and tail, while other cats had milder signs, possibly because they were diagnosed sooner. Some cats had malignant tumors, FIV infections or had been treated with corticosteroids. Affected cats usually had a history of contact with infested dogs or foxes (sometimes several months earlier), and pruritic papular rashes were often seen concurrently in the owner.

Pigs

In pigs with acute scabies, the lesions usually appear first on the head, particularly around the eyes, nose and ears. They quickly spread to the hind legs due to scratching and may become generalized. The affected skin is erythematous and inflamed, and may have macules, papules, scabs, erosions, abrasions, ulcers or cracks. It can eventually become roughened, wrinkled and thickened. The bristles are stiff and stand upright. The appetite may be depressed, and decreased growth and productivity have been reported. Secondary bacterial infections and myiasis can occur. In many pigs, the clinical signs disappear within 12 to 18 weeks without treatment.

Pigs that recover from acute scabies can carry mites in the ears. These animals may be asymptomatic or they may have small hyperkeratotic, crusted lesions in the ear canal.

Chronic scabies can affect up to 15% of infested pigs. In these animals, the skin becomes thickened and crusty, with asbestos-like scabs, particularly around the eyes and on the ears, snout, hocks, pasterns, crutch and tail. Skin folds develop on the thickened skin, which loses its sheen and becomes discolored. The hair may become long and curly in some animals and, in severe cases, there may be a foul odor. Some pigs become stunted and unthrifty. Pruritus is often less severe than in acute scabies, and mites are far more numerous.

Cattle and sheep

In cattle, the lesions may start on the head, neck and shoulders, or above the scrotum or udder and on the inner surface of the thighs. The lesions may include papules, crusts and alopecia, and the skin thickens and develops large folds. Pruritus is severe. In sheep, the lesions affect the non-woolly skin, and typically start on the head and face. Hyperkeratosis is common in goats, and the lesions usually start on the head and neck.

Horses

In horses, the earliest sign is severe pruritus. The initial lesions are usually concentrated on the head, neck and shoulders. They include papules and vesicles, which later form crusts. Alopecia, crusting and lichenification, with skin folds, are seen as the infestation progresses. Although untreated infestations can spread to the rest of the body, parts of the body protected by long hair and the lower extremities are not usually affected. Emaciation, weakness and anorexia can be sequelae.

Sarcoptidae - Notoedric mange (Feline scabies and other conditions)

Notoedric mange (*Notoedres cati*) in cats is intensely pruritic, with the possible exception of infestations in bobcats, lynxes and ocelots. The lesions typically start on the pinna of the ear, and quickly spread to the face, eyelids, back of the neck, and paws. Perineal lesions are also common, as the result of the cat's habit of sleeping in a curled position. The initial papular rash may progress to erythema, areas of partial or complete alopecia, dense tightly adherent yellow-to-gray crusts and thickened, wrinkled, hyperkeratinized skin. The lymph nodes may be enlarged. Severe untreated cases can be fatal.

Notoedres muris affects the pinnae, eyelids, nose and tail of rats, causing the skin to thicken and cornify. *Notoedres* species found in mice cause similar clinical signs.

Sarcoptidae - Trixacarus caviae

T. caviae can cause alopecia, intense pruritus and severe dermatitis in guinea pigs. Commonly affected areas include the trunk, inner thighs, neck and shoulders. The skin in affected areas may be dry or oily, with yellow scales and crusts, and the hair is easily removed. Infertility, abortions, seizures and deaths have been reported. Secondary bacterial infections may also be seen. Some infestations may be asymptomatic, and may become clinical if the animal is stressed by pregnancy, transport or other factors.

Trombiculidiasis (chiggers)

Chiggers are usually found on parts of the animal that have been in contact with the ground. They are also localized in and around the ears of cats. In dogs and cats, the bites usually result in intensely pruritic papules, which may be followed by alopecia, scales, crusts and scabs. In some cases, however, the rash may be non-pruritic. The yellow, orange or red larvae may be visible in the lesions. Horses may also

develop wheals from the allergic reaction. Large numbers of trombiculid mites on birds can result in depression, anorexia and deaths from starvation and exhaustion.

Feather mites

Feather mites rarely cause clinical signs, but it is possible that some species weaken the feathers during feeding, causing premature breakage, or produce skin lesions. In most cases, feather mites appear to result in clinical signs only when their populations become unusually large, which can lead to pruritus and feather-pulling. This has been reported only in domesticated or captive birds. Whether feather mites have any ill effects in wild birds is uncertain.

Air sac mites

Sternostoma tracheacolum is usually carried asymptomatically when there are few mites. The clinical signs in heavy infestations may include dyspnea, open-mouthed breathing, sneezing, tail bobbing, excessive saliva production in the oropharynx, and ptyalism. The signs are usually exacerbated by handling and other stressors. Heavy infestations can be fatal.

Communicability

Some mites are transmitted more readily between animals, or between different species of hosts, than others. Communicability can be influenced by the mite's survival in the environment, host specificity, and abundance on the host, among other factors. Close contact is necessary for the transmission of some mites (e.g., *Demodex* spp.). Other mites, such as *Dermanyssus gallinae*, survive well in the environment and feed on a variety of species if their preferred host is unavailable.

Human infestations with mites such as *Cheyletiella* and *Sarcoptes scabiei* are reported occasionally. The transmission rate for *S scabiei* var *canis* from dogs to people is estimated to be 10-50%, and close, prolonged skin contact is the most important route of transmission. *Cheyletiella* mites from animals are also reported to bite humans readily; however, clinical signs may not be common, or possibly not recognized. One source estimates that approximately 20% of pet owners with *Cheyletiella*-infested animals are affected. Not all mites, even those known to have zoonotic potential, will readily infest people. For example, human infestations with species such as *Ophionyssus natricis* or *Lepoacarus gibbus* appear to be uncommon.

Post Mortem Lesions

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Mites are parasites of the skin, and the lesions seen at necropsy resemble those in live animals. Secondary bacterial infections or signs of wasting may be seen in severe infestations with the Sarcoptidae and some other mites.

Diagnostic Tests

Acariasis is usually diagnosed by identifying the mites collected in skin scrapings or by other techniques. Mites are often found at the edges of lesions. They may also be detected in large numbers in areas of flaking and crusts. Some species of mites may be collected by brushing the fur, combing it with a flea comb, plucking hairs, collecting dandruff and hair tufts, or examining the material that adheres to a piece of transparent adhesive tape. A vacuum cleaner technique has also been employed to collect mites. Ear mites can be observed directly, using an otoscope, and may be collected with a cotton-tipped applicator. A technique used in reptiles is to gently rub the animal while it is standing over a piece of white paper, and to examine the paper for mites that have dropped off the animal.

Certain mites (e.g., *Sarcoptes scabiei*) may be present only in small numbers, and can be difficult to find on some hosts. Multiple skin scrapings may be necessary to detect such mites. In other cases, finding the occasional mite may be normal. Demodicosis, for example, is diagnosed only when there are increased numbers of *Demodex* spp. mites.

The diagnosis of mites that live in the environment and infest the host only while feeding can be challenging. Skin scrapings, fur and similar samples are often free of mites. Sometimes, mites such as *Ornithonyssus bacoti, Orn. sylviarum*, *Dermanyssus gallinae* and chiggers may be seen with the naked eye when they are engorged. *Orn. sylviarum* mites may be detected on the eggs, or on birds by parting the feathers in the vent region. *D. gallinae* is found in the environment during the day and on the birds at night.

Living mites can be observed by warming them to 25-30ºC (77-86ºF), which stimulates them to move. Dead mites, live mites of the smaller species, and mites in samples with large amounts of skin flakes or hair are more easily found after 10% potassium hydroxide (KOH) digestion of the sample. A flotation technique can also be used to concentrate the mites. Mites can be identified under the microscope (40X) by their shape, size and morphology, using published illustrated keys. Lignin pink or chlorazol black staining can help to highlight parasite structures or identify mites that are embedded in the tissues. Many mites can resemble each other, and they can be difficult to identify by non-specialists. Mites not readily identified using a dermatology textbook or other source can be submitted to the laboratory for identification by an entomologist.

Other diagnostic techniques are also used occasionally. Mites or their eggs are sometimes found in the feces of pruritic animals, particularly cats, by fecal flotation. *Sarcoptes scabiei* and *Notoedres cati* can also be seen in skin biopsies by histopathology. Enzyme linked immunosorbent assays (ELISAs) for *Sarcoptes scabiei* in pigs and dogs are available in some countries. Dogs with sarcoptic mange are reported to seroconvert 4-5 weeks after infestation.

Treatment

Mite infestations can be treated with various topical acaricides, or in some cases with ivermectin or other avermectins. Selamectin is reported to be effective for conditions such as sarcoptic mange, notoedric mange in cats, *Trixacarus caviae* infestation in guinea pigs, ear mites and cheyletiellosis. Before topical treatment, the animal may be bathed with an antiseborrheic shampoo to remove crusts and debris. Generally, all susceptible contacts are treated. Repeated or prolonged therapy may be necessary for certain diseases, such as generalized demodicosis. Treatment of a few reportable mite infestations (e.g., sarcoptic mange in cattle in the U.S.) must be performed under official supervision. Infestations that are resistant to acaricides, including ivermectin, have been reported.

If the mites can survive for more than a few days in the environment, the animal's surroundings must also be cleaned and treated with an insecticide or acaricide. An *Ornithonyssus bacoti* infestation of laboratory mice was treated successfully with permethrin-impregnated cotton balls placed in the mouse cages for 8 weeks, combined with spraying of the infested rooms.

Infestations with chiggers are self-limiting, and are not always treated with acaricides. The pruritus can be controlled with glucocorticoids. Mild or self-limited infestations by some mites, such as *Psorergates bos* or *Demodex bovis* in cattle, may not be treated in livestock.

Prevention

Programs involving the systematic treatment of closed populations with acaricides can eliminate some mites from animals. *Psoroptes ovis* has been eradicated from sheep in a few countries. This mite can also be eliminated from individual flocks/ herds, especially if the flock is closed. Isolation and treatment of new animals can prevent its reintroduction. Eradication is difficult, however, in flocks or herds that are allowed to mingle. Similarly, sarcoptic mange has been eliminated from some swine herds with ivermectin.

Programs have also been developed to prevent the introduction of bird mites such as *Ornithonyssus sylviarum* and *Dermanyssus gallinae* into poultry flocks. Because these mites can be carried by wild birds, as well as on infested poultry and fomites, wild birds should be excluded from the facility, and rodents should be controlled. Sanitation of fomites helps reduce the risk from this source. Flocks should be monitored weekly or bimonthly for early detection.

In rodent colonies, sentinel rodent programs may help identify infestations with some mites in the early stages. Insect sticky boards on cage racks may also be used to monitor arthropods. Wild rodents should be controlled, and measures should be taken to decrease the animals' exposure to potentially contaminated environments (e.g., by not leaving containers with rodents in a loading dock).

Repellents may be helpful for pets exposed to some mites, such as chiggers.

Morbidity and Mortality

The consequences of mite infestations range from slight (or none) to severe. In low numbers, many species of mites can be carried asymptomatically. Even in clinical cases, the effects are often not life-threatening. However, generalized or extensive infestations with some mites (e.g., the Sarcoptidae) can lead to debilitation and serious or fatal secondary bacterial infections.

Infestations with *Sarcoptes scabiei* or *Notoedres cati* can occur as epizootics, particularly in social animals, as well as sporadic cases. High morbidity and mortality rates may be seen when *S. scabiei* is introduced into a naïve population, and the infestation is not treated. In addition to debilitation and secondary bacterial infections, hypothermia may occur in winter from hair loss. Serious epizootics and population declines have been reported in some populations of wild animals, including Spanish ibex (*Capra pyrenaica*), Barbary sheep, chamois, blue sheep (*Pseudois nayaur*) and other ungulates. Wild foxes and other canids, lynx and other wild cats, wild boars, wombats, koalas and apes have also been affected. Although self-sustaining populations are expected to recover, the effect of a sarcoptic mange epizootic can be devastating in endangered species or fragmented populations.

Infestations with some other mites may also have serious consequences if their number becomes high. Large numbers of *Dermanyssus gallinae*, *Ornithonyssus bacoti* or chiggers can cause anemia, debilitation and death in birds or small rodents. Knemidocoptic mange in birds can also have serious consequences. Untreated infestations with these mites may result in deformations of the beak, mouth or feet that can affect feeding, preening or perching.

The importance of a specific mite may vary with the animal's environment. For example, *Dermanyssus gallinae* and *Ornithonyssus bursa* are mainly a problem on small rural poultry farms and in breeder flocks. They are uncommon in commercial poultry layer operations where the birds are raised in cages. In contrast, *Ornithonyssus sylviarum* is an issue even for modern poultry production facilities with high biosecurity.

Infestations in Humans

Incubation Period

Infestations with the human sarcoptic mite, *Sarcoptes scabiei* var. *hominis*, are usually mild or asymptomatic for the first 2 to 6 weeks, then become intensely pruritic once an allergic reaction develops. In later infestations, the symptoms usually appear within 1 to 4 days. In contrast, the incubation period for zoonotic *S. scabiei* infestations varies from less than 24 hours to four days, even on first exposure.

Clinical Signs

The symptoms of mite infestations and bites vary from papules and various rashes to urticaria. In most cases, the lesions are pruritic. Unusual presentations resembling other skin diseases (e.g., bullous pemphigoid) have been reported. Long-term infestations may appear atypical, and lesions caused by scratching and secondary bacterial infections may obscure the initial clinical signs.

Sarcoptes scabiei infestation

Human (non-zoonotic) scabies

The most prominent symptom of human scabies (*Sarcoptes scabiei* var *hominis*) is severe pruritus, particularly at night. In temperate climates, the head, neck, palms and soles are usually spared, except in infants and young children. In tropical regions, however, these areas are commonly affected even in adults. There may be a papular rash, particularly on the shoulder blades, webbed spaces of the fingers, feet, belt line, scrotum, penis, breast, or the folds of the wrist, elbow or knee. Pink, red, tan or brown nodules, ranging in size from 2 mm to 20 mm, are occasionally seen. These nodules are often very pruritic and may persist for several months after the mites have been treated. Burrows (thin, slightly elevated, pinkish-white or grayish-brown, 2-5 mm long straight or curved lines) are pathognomonic, but may not be visible to the naked eye. A dot at one end of the burrow indicates the presence of a mite, and a vesicle or papule may be seen where the mite entered the skin. Secondary lesions can result from scratching.

A more severe form of scabies (crusted or Norwegian scabies) is found mainly (but not exclusively) in immunocompromised persons, the elderly, and people who have physical or mental conditions that reduce pruritus or scratching (e.g., paralysis, sensory defects, and mental impairment). In this form, there are large numbers of mites, discrete vesicles and extensive crusts on affected areas of the skin, but pruritus may be slight or absent. Nail dystrophy and scalp lesions may also be seen.

Secondary bacterial infections, mainly from *Streptococcus pyogenes* and *Staphylococcus aureus*, can complicate scabies.

Zoonotic scabies

Zoonotic scabies is also highly pruritic, but the lesions usually occur in areas that contacted the animal, such as the arms, chest, abdomen and thighs. In humans, the zoonotic varieties of *S. scabiei* are generally believed to cause vesicles, papules and other symptoms of dermatitis, but not classic burrows. Zoonotic scabies is almost always self-limiting; the mites usually disappear within a few days, and the clinical signs resolve in 1 to 3 weeks unless the person becomes reinfested.

A few atypical cases have been documented. There is one report of crusted scabies in a child caused by *S. scabiei* var *canis*. There was also an unusual case, also thought to be caused by a canine scabies mite, where the lesions continued to spread for several weeks in a human after animal contact stopped. In this case, mites and their eggs (which were capable of hatching) were found on the person. It is possible that the mite was misidentified and this was actually a case of human scabies that had been transmitted to a dog, then back to a human.

Other Sarcoptidae

Notoedres cati causes signs similar to zoonotic *S. scabiei* in humans. The infestation is self-limiting within several weeks. *Trixacarus caviae*, a parasite of guinea pigs, has been reported to cause pruritic papulovesicular skin lesions in some people.

Cheyletiella

Cheyletiella spp. can cause a pruritic, mild dermatitis in people. The lesions are seen mainly in areas that were in contact with the pet, such as the abdomen, chest, arms and legs. Papules (which become pustules), erythema and pruritus are the most common signs, but macules, plaques, vesicles or crusts may also occur. Central necrosis in older lesions is highly suggestive of cheyletiellosis, but it is not always seen. Some lesions may resemble hives, erythema multiforme or herpes. Bullae have been reported in rare cases. Peripheral eosinophilia, immune complexes with joint pain, and numb fingertips with a decreased range of motion, together with a pruritic skin rash, were described in one unusual case. Cheyletiellosis lesions are self-limiting, and resolve after the infested pet is treated.

Macronyssidae and Dermanyssidae

The bites of species such as *Dermanyssus gallinae*, *D. americanus*, *D. hirundinis*, *Liponyssoides sanguineus*, *Ornithonyssus bacoti*, *Orn. sylviarum* and *Orn. bursa* may be mildly to intensely painful, and are often pruritic. They can also result in localized dermatitis. Papules are the most common lesion, but macules, diffuse erythema, vesicles, urticaria and hemorrhagic necrosis may also be seen. In cases of severe dermatitis, the area may remain swollen for days. The snake mite *Ophionyssus natricis* caused a vesiculopapular rash, mainly on the upper extremities, in a family with an infested python.

L. sanguineus can transmit *Rickettsia akari*, which causes human vesicular rickettsiosis (rickettsialpox). Mites in the families Macronyssidae and Dermanyssidae have also been implicated as potential vectors for other agents, including those that cause Western and Eastern equine encephalomyelitis, St. Louis encephalitis, murine typhus, scrub typhus, endemic typhus, Q fever, plague and tularemia. However, they are not known to be important in transmitting these organisms in the field.

Trombiculidae (chiggers)

When a person is first exposed to chiggers, the bites may be asymptomatic. However, the development of allergic reactions leads to clinical signs. The first symptom of a chigger bite is usually a tiny red papule, typically in

clusters, accompanied by intense and painful pruritus. Vesicles and bullae may be found if the allergy is intense. Some bites can remain painful for a week or longer. Commonly affected sites include the ankles, the areas between the toes and behind the knees, and the borders of undergarments and other sites where clothing restricts the mites' progress. Hypersensitivity reactions that result in swelling of the penile and scrotal area can lead to dysuria.

Some species of chiggers transmit scrub typhus (*Orientia tsutsugamushi* infection), in regions where this parasite is endemic.

Communicability

Human scabies caused by *S. scabiei* var *hominis* is usually transmitted from person to person during close contact (including sexual transmission). This mite is occasionally transmitted on fomites. The latter route is more common with the crusted form, where large numbers of mites are present. The mites can be highly contagious in some settings.

The zoonotic mites do not reproduce on humans; however, some of these mites can survive for prolonged periods in the environment, and humans may act as fomites.

Diagnostic Tests

Human (non-zoonotic) scabies

Human scabies is usually diagnosed clinically by pruritus, the appearance of the rash and the presence of burrows, especially when there is a history of contact with a scabies case. Burrows can be revealed by applying topical tetracycline, which is retained by the burrows and fluoresces under a Woods lamp. They may also be localized with ink. However, burrows are not always easy to find, and they may be obscured by secondary lesions. This disease can be confirmed by the demonstration of the mites, eggs or feces in a skin scraping (or by the removal of a mite from a burrow), under 40X magnification. Epiluminescence microscopy and high-resolution videodermatoscopy of the skin may be helpful, if they are available.

Zoonotic mites

Zoonotic scabies and other mite infestations are also diagnosed in humans by identifying the mites; however, finding any mites is often difficult. Transparent tape can be used to pick up mites from the skin. An important diagnostic clue is the presence of mites on animals, even when they are not detected on the affected person. *Cheyletiella* spp. are reported to return quickly to the infested animal after biting a human. A diagnostic video system was used successfully in at least one case of human cheyletiellosis, when other diagnostic methods failed.

Dermanyssus gallinae (and other Macronyssidae and Dermanyssidae) sometimes appear as red dots on the skin when they are feeding, and may be visible in the environment. When they are not engorged with blood, *D. gallinae* mites are white, black or gray. They often leave the body quickly after a blood meal. They may be found in homes by vacuuming the area and examining the dust by flotation (the mites will float to the surface).

Treatment

Human (non-zoonotic) scabies

A variety of agents can be used to treat scabies, depending on the patient's age, health, degree of excoriation or eczema, and type of scabies (e.g., crusted or ordinary scabies), as well as the potential toxicity of the drug, its cost and availability. Acaricides used to treat human scabies include topical lotions containing permethrin, crotamiton, benzyl benzoate or other agents, and oral ivermectin. Some acaricides are licensed for scabies treatment in some nations but not others (e.g., benzyl benzoate is approved in Europe, but not the U.S.) or are considered to be investigational. Topical lindane (gammabenzene hexachloride) was once the most common treatment for scabies, but other agents are now usually preferred due to concerns about neurotoxicity. Occasionally, mites may be resistant to some drugs, including permethrin and ivermectin.

In the crusted form, adjunct therapies are often used to improve the penetration of topical drugs and reduce the number of mites. This may include warm water soaks, a keratolytic agent, and mechanical debridement.

Pruritus can persist for a few weeks after successful treatment. Oral antihistamines and topical antipruritics/ anesthetics can be used to treat the pruritus. Antibiotics may be necessary for secondary infections.

Zoonotic mites

Because zoonotic mites do not usually persist and reproduce on human skin, infestations with these mites typically require only symptomatic therapy such as anti-pruritic or anti-inflammatory medications (e.g., anti-histamines, topical corticosteroids, topical anesthetics). Adjunct therapies, such as cleansing with soap and water, and warm water soaks, may be helpful in some infestations (e.g., chiggers). Bathing removes some mites, such as *Ornithonyssus bacoti*.

Treatment of the affected animals and/or the environment will eliminate the infestation in human contacts.

Prevention

Human (non-zoonotic) scabies

When a case of scabies is identified, close personal contacts who have had prolonged skin-to-skin contact during the previous month, as well as the members of the infested person's household, should be evaluated for scabies and treated. Any bedding, towels and clothing used during the previous 3 days (before treatment) should be decontaminated. In cases of crusted scabies, rooms should be thoroughly cleaned and vacuumed to remove skin flakes and mites. The CDC does not recommend treatment of the environment with insecticides.

Zoonotic mites

Zoonotic acariases can be prevented by treating the infested animals. Gloves and protective clothing can decrease the risk of transmission when handling affected animals. Human contacts of people infested with zoonotic scabies mites do not have to be treated.

The mites from wild birds and rodents are best controlled by preventing animals from nesting and roosting near the home (e.g., on top of window air conditioners), and by controlling rodent pests. Insecticides and foggers can treat current infestations around the home.

Insect repellents can help prevent infestation by chiggers. Avoidance of forested and swampy areas, particularly during the late summer and early fall, will also reduce the risk of exposure. Insect repellants and protective clothing may also be helpful when working in environments infested with poultry mites.

Morbidity and Mortality

Human (non-zoonotic) scabies

S. scabiei var *hominis* is most common in children, sexually active persons, and debilitated or immunocompromised individuals. Crowding facilitates outbreaks and pandemics. Untreated secondary bacterial infections can result in serious or fatal sequelae including glomerulonephritis, acute rheumatic fever and septicemia. With modern medicines, scabies is unlikely to result in long-term morbidity or mortality in healthy people, but untreated infestations can last for weeks to years. Crusted scabies has a higher mortality rate, due to an increased incidence of secondary bacterial infections. This form is also more difficult to treat.

The cause of crusted scabies is uncertain. Ordinarily, the host reaction is thought to limit the number of mites. Consistent with this, crusted scabies has been associated with immunosuppression, and with diseases such as leprosy (or a previous case of leprosy). Other cases are linked to mental or physical limitations that result in the absence of pruritus or a scratch response. However, cases are occasionally seen in people who are apparently immunocompetent and have no other predisposing factors. Familial clusters have been reported, suggesting the possibility of genetic influences on susceptibility.

Zoonotic mites

Zoonotic mites do not reproduce on humans, and produce a self-limiting rash. The only morbidity is the temporary pruritus and discomfort, and infestations are not expected to be fatal.

Internet Resources

Centers for Disease Control and Prevention (CDC). Parasites
http://www.cdc.gov/parasites/az/index.html#s

CDC Scabies
http://www.cdc.gov/parasites/scabies/index.html

International Veterinary Information Service (IVIS)
http://www.ivis.org

The Merck Manual
http://www.merckmanuals.com/professional/index.html

The Merck Veterinary Manual
http://www.merckvetmanual.com

World Organization for Animal Health (OIE)
http://www.oie.int/

OIE Manual of Diagnostic Tests and Vaccines for Terrestrial Animals
http://www.oie.int/en/international-standard-setting/terrestrial-manual/access-online/

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