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Arthropoda

Acari (Order): Mites

David Evans Walter, Gerald W. Krantz, and Evert E. Lindquist

Phylum Arthropoda

Order Acari

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Chapter 67

Acari (Order): Mites

David Evans Walter

Faculty of Medicine and Dentistry, University of Alberta, Edmonton, Alberta, Canada

Gerald W. Krantz

Department of Integrative Biology, Oregon State University, Corvallis, Oregon, United States

Evert E. Lindquist

Research Branch of Agriculture and Agri-Food Canada, Ottawa, Ontario, Canada

Introduction

Mites (order Acari or order Acarina) are the most diverse and abundant of all arachnids, but because of their small size (usually less than a millimeter in length) they are rarely seen. Red velvet mites are among the giants of the Acari (up to 10 mm) and can often be seen hunting on the ground or on tree trunks. Water mites are rarely more than a few millimeters long, but their bright colors and rapid movement are eye-catching. At the smaller end of the mite size range are species like the human hair follicle mite *Demodex folliculorum* or the honeybee tracheal mite, small enough to raise a family within a human hair follicle or within a bee's respiratory tube, and too small (about 0.1 mm) to see without a microscope.

Mites are also among the oldest of all terrestrial animals, with fossils known from the early Devonian Era, nearly 400 Ma (= million years ago; Norton et al., 1988; Kethley et al., 1989). Three major lineages are currently recognized: superorders Opilioacariformes, Acariformes, and Parasitiformes (Krantz, 1978; Johnston, 1982; Evans, 1992). About 45,000 species of mites have been described; a small fraction (perhaps 5%) of the number of species estimated to be alive today.

Mites are truly ubiquitous. They have successfully colonized nearly every known terrestrial, marine, and freshwater habitat including polar and alpine extremes, tropical lowlands and desert barrens, surface and mineral soils to depths of >10 m, cold and thermal surface springs and subterranean waters with temperatures as high as 50 °C, all types of streams, ponds and lakes, and sea waters of continental shelves and deep-sea trenches to depths of 5,000 m. Some idea of mite abundance and diversity can be gained from analysis of 1 square m of mixed temperate hardwood or boreal coniferous litter, which may harbor upwards from 1 million mites representing 200 species in at least 50 families. Within this complex matrix of decomposing plant matter, mites help to regulate microbial processes directly by feeding on detritus and microbes, and indirectly by predation on other microfauna.

Many mites have complex symbiotic associations with the larger organisms on which they live. Plants, including crops and the canopies of tropical rainforests, are inhabited by myriads of mite species feeding on mosses, ferns, leaves, stems, flowers, fruit, lichens, microbes, other arthropods, and each other. Many mites found on agricultural crops are major economic pests (for example, spider mites) or useful biocontrol agents (for example, phytoseiid mites) of those pests. Mammals and birds are hosts to innumerable species of parasitic mites (for example, scabies and mange mites), as are many reptiles and some amphibians. Insects, especially those that build nests, live in semipermanent habitats like decaying wood, or use more ephemeral habitats like bracket fungi and dung, are hosts to a cornucopia of mite commensals, parasites, and mutualists. None of these mites exceed a cm in length, and the vast majority grow to less than a mm, yet they often have a major impact on their hosts.

Characteristics

The Acari can be defined by the following characteristics:

- Hexapod prelarva (lost in Parasitiformes and many derived Acariformes)
- Hexapod larval stage
- Three octopod nymphal stages (variously abbreviated in derived taxa)
- Gnathosoma delimited by a circumcapitular suture
- Palpcoxal endites fused medially forming a hypostome
- Hypostome with rutella or corniculi (lost in many derived Acariformes)
- Loss of external evidence of opisthosomal segmentation, that is, without tergites or sternites
- Ingestion of particulate food (lost in many derived taxa).

Figures 1–3 include images of morphological characters of mites.

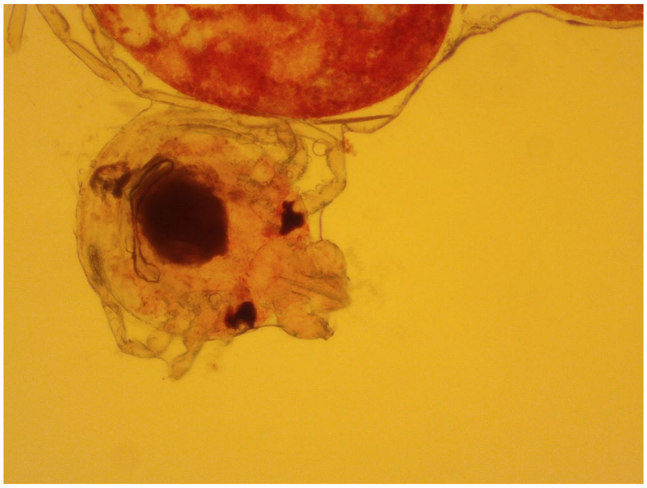

Figure 1. Larval mite of the genus *Hydrachna* that was removed from the wing of a backswimmer (genus *Notonecta*). The lateral dark spots are the eyes. Source: S. L. Gardner, HWML. License: CC BY.

Figure 2. *Ornithonyssys bacoti*, a mite (Acari: Mesostigmata: Macronyssidae) from the skin of a rodent (*Microtus ochrogaster*) collected at Cedar Point Biological Station, near Ogallala, Nebraska, United States, 2015. Source: S. L. Gardner, HWML. License: CC BY.

Scabies

Scabies is an infestation of the skin by the human itch mite (*Sarcoptes scabiei* var. *hominis*). The microscopic scabies mite burrows into the upper layer of the skin where it lives and lays its eggs. The most common symptoms of scabies are intense itching and a pimple-like skin rash. The scabies mite usually is spread by direct, prolonged skin-to-skin contact with a person who has scabies.

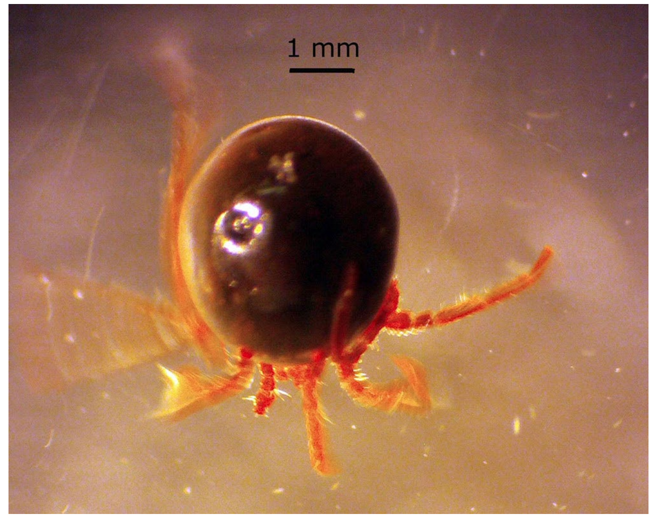

Figure 3. Aquatic mite, adult female collected from a cattle tank in the Sandhills of southwestern Nebraska, United States. The adults are free-living and the larvae are parasitic on backswimmers. Source: S. L. Gardner, HWML. License: CC BY.

Scabies is found worldwide and affects people of all races and social classes. Scabies can spread rapidly under crowded conditions where close body and skin contact is frequent. Institutions such as nursing homes, extended-care facilities, and prisons are often sites of scabies outbreaks. Child-care facilities also are a common site of scabies infestations.

Causal Agent of Scabies

Sarcoptes scabiei var. *hominis* is in the arthropod class Arachnida, order Acari, family Sarcoptidae. The mites burrow into the upper layer of the skin but never below the stratum corneum. The burrows appear as tiny raised serpentine lines that are grayish or skin-colored and can be a cm or more in length. Other races of scabies mites may cause infestations in other mammals, such as domestic cats, dogs, pigs, and horses. It should be noted that races of mites found on other animals may cause a self-limited infestation in humans with temporary itching due to dermatitis; however, they do not multiply on the human host.

Life Cycle of *Sarcoptes scabiei* var. *hominis* (Figure 4)

Sarcoptes scabiei undergoes 4 stages in its life cycle: Egg, larva, nymph, and adult. Females deposit 2–3 eggs per day as they burrow under the skin. Eggs are oval and 0.10 to 0.15 mm in length and hatch in 3 to 4 days. After the eggs hatch, the larvae migrate to the skin surface and burrow into the intact stratum corneum to construct almost invisible, short burrows called molting pouches. The larval stage, which emerges from the eggs, has only 3 pairs of legs and lasts about 3 to 4

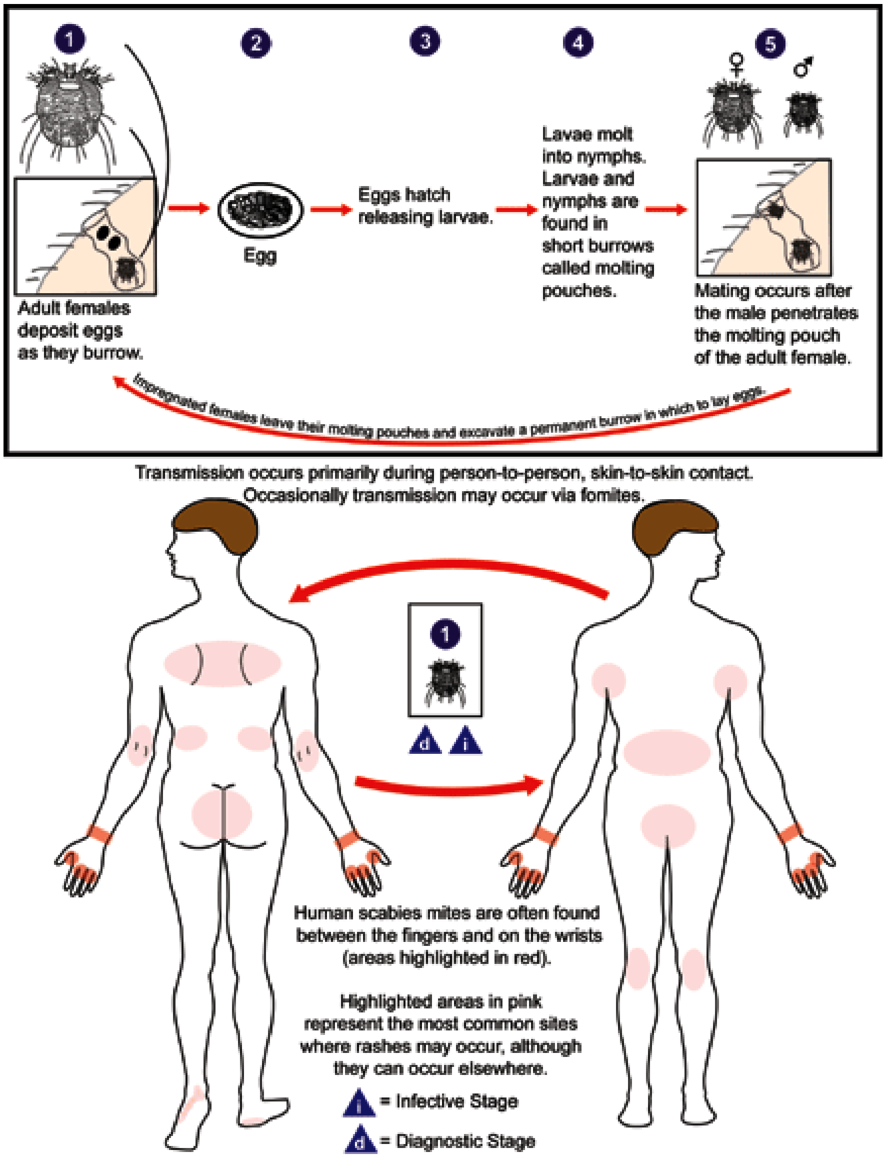

Figure 4. *Sarcoptes scabiei* life cycle. *Sarcoptes scabiei* undergoes 4 stages in its life cycle: Egg, larva, nymph, and adult. Females deposit 2–3 eggs per day as they burrow under the skin (1). Eggs are oval and 0.10 to 0.15 mm in length (2) and hatch in 3–4 days. After the eggs hatch, the larvae migrate to the skin surface and burrow into the intact stratum corneum to construct almost invisible, short burrows called molting pouches. The larval stage, which emerges from the eggs, has only 3 pairs of legs (3) and lasts about 3–4 days. After the larvae molt, the resulting nymphs have 4 pairs of legs (4). This form molts into slightly larger nymphs before molting into adults. Larvae and nymphs may often be found in molting pouches or in hair follicles and look similar to adults, only smaller. Adults are round, sac-like eyeless mites. Females are 0.30 to 0.45 mm-long and 0.25 to 0.35 mm-wide, and males are slightly more than half that size. Mating occurs after the active male penetrates the molting pouch of the adult female (5). Mating takes place only once and leaves the female fertile for the rest of her life. Impregnated females leave their molting pouches and wander on the surface of the skin until they find a suitable site for a permanent burrow. While on the skin's surface, mites hold onto the skin using sucker-like pulvilli attached to the 2 most anterior pairs of legs. When the impregnated female mite finds a suitable location, it begins to make its characteristic serpentine burrow, laying eggs in the process. After the impregnated female burrows into the skin, she remains there and continues to lengthen her burrow and lay eggs for the rest of her life (1–2 months). Under the most favorable of conditions, about 10% of her eggs eventually give rise to adult mites. Males are rarely seen; they make temporary shallow pits in the skin to feed until they locate a female's burrow and mate. Transmission occurs primarily by the transfer of the impregnated females during person-to-person, skin-to-skin contact. Occasionally transmission may occur via fomites (for exam-ple, bedding or clothing). Human scabies mites often are found between the fingers and on the wrists. Source: United States Centers for Disease Control and Prevention, Division of Parasitic Diseases and Malaria, 2017. Public domain.

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Some immunocompromised, elderly, disabled, or debilitated persons are at risk for a severe form of scabies called crusted, or Norwegian, scabies. Persons with crusted scabies have thick crusts of skin that contain large numbers of scabies mites and eggs. The mites in crusted scabies are not more virulent than in non-crusted scabies; however, they are much more numerous (up to 2 million per patient). Because they are infested with such large numbers of mites, people with crusted scabies are very contagious to other people. In addition to spreading scabies through brief direct skin-to-skin contact, persons with crusted scabies can transmit scabies indirectly by shedding mites that contaminate items such as their clothing, bedding, and furniture. Persons with crusted scabies should receive quick and aggressive medical treatment for their infestation to prevent outbreaks of scabies.

Phylogenetic Relationships (based on research through 1996)

Traditionally, the mites have been treated as a subclass of the Arachnida, and 3 major lineages have been recognized, though the names used to refer to these groups have varied considerably (Krantz, 1978; Johnston, 1982; Evans, 1992). Here the names are generally followed as used in Parker (1982), and consider 3 superorders (sensu Evans, 1992) of Acari that exist. The superorder Opilioacariformes consists of a single order and family (Opilioacarida, Opilioacaridae) with about 20 known species. The superorder Acariformes contains over 300 families and over 30,000 described species. Two major lineages are recognized, the Sarcoptiformes (Oribatida and Astigmata) and Trombidiformes (Prostigmata). Additionally, 8 families of very early derivative acariform mites are lumped into the Endeostigmata, usually considered a suborder of the Prostigmata, but clearly containing taxa that belong to both major acariform lineages. The superorder Parasitiformes consists of 3 orders: Ixodida, Holothyrida, and Mesostigmata. The Mesostigmata contains in excess of 65 families and 10,000 described species, the other 2 parasitiform orders each comprise 3 families. About 850 species of ticks are known, but only about 30 species of holothyrans have been recognized.

What then is a mite? Aside from being generally tiny chelicerate arthropods with hexapod larvae, a discrete gnathosoma, and a loss of primary segmentation, mites are difficult to characterize. Lindquist (1984) pointed out that many of the characters used to define mites were present in other chelicerate orders, especially in the Ricinulei. He proposed 11 apomorphic characteristics for the Acari (Lindquist, 1984, Table 8, p. 40), but several of these character states are not present in the Parasitiformes and presumably have been secondarily lost. It seems that mites often are most easily recognized by what they are not, other arachnids, rather than by a discrete set of acarine characters.

Among acarologists, arguments about monophyly or diphyly of the Acari have yet to be resolved, although currently the monophyleticists seem to be dominant (see Lindquist, 1984; Evans, 1992). The Parasitiformes and Opilioacariformes are thought to be sister groups, and in turn this taxon (the Anactinotrichida, so named because of the absence in their setae of optically active actinochitin) is considered the sister group of the Acariformes (also called the Actinotrichida). Outside of the acarological community, those interested in chelicerate phylogeny have tended to assume that the Acari were a monophyletic assemblage (for example, Weygoldt and Paulus, 1979; Shultz, 1990; Weygoldt, 1998).

Many acarologists have concluded that mites are closely related to the arachnid order Ricinulei (Lindquist, 1984; van der Hammen, 1989; Evans, 1992). Weygoldt and Paulus (1979) first proposed a sister group relationship between the Ricinulei and the Acari and named this taxon the Acarinomorpha. Schulz (1990) also supported this relationship, but like Weygoldt and Paulus, assumed that the Acari are monophyletic. Van der Hammen (1989) considered the Acari to be diphyletic, and the Acariformes and Parasitiformes to be at most only distantly related. According to van der Hammen, the Ricinulei and Anactinotrichida (Parasitiformes + Opilioacariformes) are sister groups and, within another lineage, the Actinotrichida (Acariformes) and the non-acarine Palpigradi also are sister groups. Lindquist (1984) presented four derived characters linking the Acari and Ricinulei (Lindquist, 1984, Table 9, p. 41) and concluded that, within the Acari proper, the Opilioacariformes and Parasitiformes form a sister group to the Acariformes.

Lindquist's (1984) hypothesis is followed here, which suggests that a monophyletic lineage includes the Ricinulei and the Acari. This hypothesis is based on the characters presented by Lindquist and is in agreement with that of Weygoldt and Paulus (1979) and Schulz (1990), but not with that proposed by Dunlop (1996).

Other Names for the Acari

Other names for the Acari include Acarina, Acaroides, Acaromorpha, Milben, acariens, acaros, Acarida, and mites.

Scope Note for This Textbook Section

This section was adapted by the textbook editors (S. A. Gardner and S. L. Gardner) from Walter and colleagues (1996), an open access contribution to the Tree of Life Web Project made available online under a CC BY-NC 3.0 license, and the public domain United States Centers for Disease Control and Prevention webpages on scabies (CDC, 2020). Since 1996, several other investigations into Acari systematics and genomics have been conducted, so other sources should be consulted to supplement this introduction to the topic.

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