

Human hair follicle mites and forensic acarology

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Abstract The hair follicle mites of the genus *Demodex* (Demodecidae) were first discovered in humans in 1841. Since then, members of this host-specific genus have been found in 11 of the 18 orders of eutherian mammals with most host species harboring two or more species of *Demodex*. Humans are host to *D. folliculorum* and *D. brevis*. The biology, natural history, and anatomy of these mites as related to their life in the human pilosebaceous complex is reviewed. This information may provide insight into the application of *Demodex* as a tool for the forensic acarologist/entomologist.

Keywords *Demodex* · Follicular mite

Historical background

On 2 November 1841 and, again, on 14 February 1842, Berger submitted sealed packets to the Academy of Science in Paris, France. Upon Berger's instruction both documents remained unopened until 12 May 1845 when he was admitted to membership in the Academy. The papers revealed his finding of an organism in the earwax of the outer ear canal of man. He considered this organism to be a member of the phylum Tardigrada (Berger 1845; see Gmeiner 1908).

In December 1841, Frederick Henle (1809–1885), working in Zurich, Switzerland, reported this parasite from the miliary glands ('die Hautdrüse') of the ear canal. He preferred to remain uncertain as to the parasite's systematic position (Gmeiner 1908). Henle was the first to describe the histology of the human skin. Also, he believed that contagious diseases were caused by live organisms. His student, Robert Koch, subsequently proved him correct. Henle is also remembered for his 'loop' of the vertebrate nephron.

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The following March, 1842, Gustav Simon (1824–1876) in Berlin, Germany, obtained this parasite from the hair follicles on the face and recognized it as a mite naming it *Acarus folliculorum* (Simon 1842). His drawings and lengthy description included various life stages, but he did not arrange these in developmental order. Simon was a medical doctor by profession who specialized in closing vesicovaginal fistulas and he performed in 1869 the world's first successful intentional nephrectomy.

Richard Owen (1804–1892), the first director of the British Museum (Natural History) in London, UK (now Natural History Museum), placed this mite in its own genus, *Demodex*, coined from the Greek 'demo' (=lard) and 'dex' (=boring worm) (Owen 1843). As a vertebrate anatomist, Owen was the first to describe *Archaeopteryx lithographica*, coined the word 'dinosaur', and introduced the concept of homology. He is of great notoriety for his vehement opposition to evolution and its means by natural selection as proposed by Charles Darwin and Alfred Russell Wallace.

Erasmus Wilson (1809–1884), a dermatologist in England, submitted a lengthy description of the human hair follicle mite to the Royal Society (London) in December 1842, which was revised in 1843, and published in 1844 (Wilson 1844). He, as with Simon, noted the polymorphic nature of the parasite and suggested there are two species infesting human skin. Although aware of Simon's work, he did not consider *Demodex* to be a mite, but was unable to determine the systematic position of the parasites. He selected his own name for the parasite, *Entozoon folliculorum*.

Jean-Pierre Megnin (1828–1905), a French veterinary parasitologist, named and very briefly described *Demodex cati* from the domestic cat (Megnin 1877). Megnin is connected to modern forensic science by his 1894 paper describing eight stages of corpse decay (in open air) with characteristic arthropod successional stages (Keh 1985). Each stage had a minimal time period, thus he could roughly estimate the time of death.

The first complete life cycle of a hair follicle mite was elucidated by Frank French in 1963, in the USA, while studying *Demodex canis* of the domestic dog. He recognized the following stage sequence: ovum, hexapod larva, hexapod protonymph, octopod nymph, and adult, respectively (French 1963). A few species are known to lack the protonymphal stage, e.g., *D. gapperi* and *D. antechini*. Also in that year, L. Akbulatova, in Russia, concluded that the polymorphic nature of the human hair follicle mites actually represented two forms which she gave subspecific status: *D. folliculorum longus* and *D. folliculorum brevis* (Akbulatova 1963). Clifford Desch and William Nutting, in the USA, elevated these to specific rank: *D. folliculorum* (Simon) and *D. brevis* Akbulatova (Desch and Nutting 1972).

By 1908, Gmeiner could list 13 species of *Demodex* described from wild and domestic mammals. Stanley Hirst (1919), of the British Museum, added seven more species to this list in his classic 1919 monograph on the hair follicle mites. By 1960, 32 species had been named. To date, 86 species have been described from hosts in three of the seven marsupial orders, and in 11 of the 18 eutherian orders. This wide range of host orders encompasses 97% of all extant mammal species.

Incidence of hair follicle mites in humans

Shortly after the initial discovery of hair follicle mites in humans, it was observed that most individuals harbor these parasites. Simon (1842) found mites on the faces of three of ten live persons and eight of ten cadavers. The two negative cadavers were new-borns. Gmeiner (1908) recovered mites from 97 of 100 cadavers. The three negatives were a 9-year-old girl, and 2- and 8-day-old infants. He obtained similar results with a second set of 100 cadavers.

He reported an incidence of 50–60% when examining eyelashes only. Gmeiner concluded that demodexids are found on the face of every human being with the exception of the new-born. Francois Fuss (1933), in France, corroborated this with finding 100% incidence in a sample of 100 cadavers ranging in age from 1 to 82 years, and consisting of 50 females, 31 males, and 16 infants. Mogens Norn (1970), in Denmark, examined four eyelashes from each lid of 100 cadavers and found 89% infestation, which increased to 100% in individuals 80+ years old. He found no incidence difference between sexes.

The above studies were done before the distinction of *Demodex folliculorum* and *D. brevis* (Desch and Nutting 1972). Sengbusch and Hauswirth (1986) and Sengbusch (1991) considered the prevalence of these mites based on host race, age, and sex in the Buffalo, NY (USA) area. Their 1986 sample of 370 live persons showed 57% of Caucasians and 46% of African-Americans harbored the mites. The average for the entire sample for one or both species was 55%, consisting of 31% with *D. brevis* only, 11% with *D. folliculorum* only, and 14% with both. Although hair follicle mites have been found on all human races examined to date (Sengbusch 1991), the incidence rates from living persons vary from report to report and from different groups sampled, e.g., 7.6% in Tokelau Islanders (Andrews 1988) to the 55% in western New York (Sengbusch and Hauswirth 1986).

Locus of human hair follicle mites on the body

Most human hair follicle mites are recovered from the facial area including the ear canal, eyelashes, nose and alar region, and the forehead. Chambers and Somerset (1925) reported 60% incidence in breast samples removed from breast cancer patients in England. Earlier work in France by Borrel (1909) recorded similar infestation rates in tissue of the nipple. These mites also have been recovered from the knee area of the leg (Vance 1981), ectopic sebaceous glands on the tongue (Trodahl et al. 1967), and even the foreskin of a man circumcised at age 70 (Breckenridge 1953).

Within the pilosebaceous complex, *D. folliculorum* resides in the hair follicle next to the hair shaft above the level of the sebaceous gland and with its dorsum towards the hair shaft. *Demodex brevis* is found in the sebaceous glands of the hair follicles (Desch and Nutting 1972).

Mite survival following death of the host

Various investigators have made anecdotal comments regarding survival of *Demodex* following the host's death. Wilson (1844) stated '...I have found them alive in a subject in the dissecting room that had been dead for 14 days'. Gmeiner (1908) reported live mites adhering to eyelashes '...obtained from corpses in which they had kept living for many days'. Chambers and Somerset (1925) found live mites in breast tissue 8 days post operation (mastectomy), stored at room temperature and '...in which autolytic changes have been well advanced'.

Demodex as a potential forensic tool

The universal presence of human hair follicle mites in all races and age groups, except the new-born, and their survival of more than a week postmortem of the host are factors

making *Demodex* a potential tool in forensic entomology (acarology). In a situation in which a cadaver was in a space from which arthropod carrion feeders were excluded, including air, water, and soil, estimating time of death may be facilitated by the finding of live hair follicle mites.

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