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Review Article

Epidemiology of infections due to zoophilic dermatophyte *trichophyton simii*, an update

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ABSTRACT

Trichophyton simii is an important zoophilic dermatophyte. It has two different names, one for the asexual form (the anamorph state) that occurs in the vertebrate host, and the other for the sexual form (teleomorph also called "perfect state") produced by mating between anamorphs. The sexual state of *T. simii* belongs to the genus Arthroderma in the family Arthrodermataceae of the phylum Ascomycota of the Kingdom fungi. Zoophilic *Trichophyton* species include *Trichophyton equinum*, *T. bullosum*, members of the *T. mentagrophytes* complex, *T. simii*, and *T. verrucosum*. The clinical lesions caused by *T. simii* in humans and animals are usually inflammatory and erythematous. It can be distinguished from other Trichophyton species by its faster growth on agar media, forming finely granular colonies with white-to-pale yellow color on reverse and distinctive to fusiform 3–7 septate macroconidia converting into chlamydospores in older cultures, and pyriform microconidia, and inability to perforate hair in-vitro, and produce the enzyme urease. *Trichophyton simii* is known to infect monkeys, chickens, dogs, and humans worldwide, though infections are sporadic and epidemic potential and zoonotic risk for humans is low; this dermatophyte is also known to occur as a geophilic species in several countries. The literature search generated a lot of data on *T. simii* infections from several countries, namely India, Sri Lanka, Japan, Iraq, Iran, Saudi Arabia, Belgium, France, the USA, and Brazil; many of the reports lacked details of clinical lesions and did not mention about treatment/outcome of infections. The results are analyzed and presented concisely in the tables. There is need for investigating the epidemiology of *T. simii* infections in countries from where, human *T. simii* infections have been reported, and occurrence of this dermatophyte in soil by employing conventional mycological methods and a newly developed PCR technique based on ITS genomic sequences of this dermatophyte.

Keywords: Trichophyton simii, Infections, Epidemiology, An update

INTRODUCTION

Dermatophytes are a morphologically related group of filamentous fungi that invade the keratinized layers (stratum corneum and stratum lucidum) of the skin hair, nails, feathers, horns, and hooves. The species of dermatophytes belong to three genera: *Microsporum*, *Trichophyton* and *Epidermophyton*. Dermatophytes, like many other fungi, may have two different species names. One name belongs to the asexual form (the anamorph state) that occurs in vertebrate hosts. The other name given to the sexual form of the organism is called the teleomorph or the "perfect state," produced by mating between anamorphs.[1] The teleomorph (perfect) states of both *Microsporum* and *Trichophyton* belong to the genus *Arthroderma*. The dermatophytes known to have sexual states are placed in family Arthrodermataceae of the phylum Ascomycota of the Kingdom Fungi. The dermatophytes with no known sexual state, like other medically important fungi with this

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feature are classified as Deuteromycota (Fungi Imperfecti).[1] Dermatophytoses occur frequently in livestock, in other domestic animals, and in wild animals. Infections caused by zoophilic dermatophytes are generally mild and self-limiting. These respond well to treatment; they rarely manifest as serious and systemic infections in immunocompromised hosts.[1] The prevalence of dermatophytosis in animals varies greatly according to geographic locale. Zoophilic *Microsporum* species include *Microsporum canis*, *M. gallinae*, and *M. persicolor*. Horse-adapted isolates of *M. canis*, which are negative for the in-vitro hair perforation test (unlike most *M. canis*) and produce few conidia, were formerly called *M. equinum*. Based on genetic relatedness, they are now considered to be *M. canis.* Members of *Trichophyton* include *Trichophyton equinum*, *T. bullosum*, members of the *T. mentagrophytes* complex, *T. simii*, and *T. verrucosum.*[1] Most or all of zoophilic dermatophytes infect animals (thus termed zoonotic), although some are transmissible to humans more often than others.[2] *Trichophyton simii* was first isolated from the vesicular cutaneous lesions of a monkey (imported from India) in France.[3] Later it was recovered from skin lesions of a monkey in the USA;[4] the monkey had been imported from India. Stockdale et al.[5] studied 29 isolates received from Prof, N.F. Conant; these isolates had been recovered from chickens (27), dog (1) and a poultry attendant (1) by Prof C.M. Singh, College of Veterinary Medicine & A.H., Mathura (UP, India). One of the isolates from chickens formed cleistothecia (perfect state) characteristic of the genus *Arthroderma*.[5] Phenotypic identification of *Trichophyton simii* (anamorph of *Arthroderma simii*) is based on the formation of finely granular colonies in culture with white-to-pale yellow color on reverse and distinctive to fusiform 3–7 septate macroconidia converting into chlamydospores in older cultures, and pyriform microconidia.[6] It can be distinguished from other Trichophyton species by its faster growth on agar media, inability to perforate hair in-vitro utho, and produce the enzyme urease.[6–8] The clinical lesions caused by *T. simii* in humans and animals are usually inflammatory and erythematous. *Trichophyton simii* is known to infect monkeys, chickens, dogs, and humans worldwide, though infections are sporadic and epidemic potential and zoonotic risk for humans is low.[9] This dermatophyte is also known to occur as a geophilic species in India and Ivory Coast.[10]

Search criteria

An exhaustive search of the literature was made in Google search Engine and PubMed electronic database by using several sets of keywords, viz**.** *Trichophyton simii,* Trichophyton infections in animals and humans, India, Asia, Europe, North America, South America. The Boolean Operator AND was used to compare and narrow the searches. Cross references were also consulted for extracting relevant information.

Literature review

The literature search generated a lot of data on human and animal infections due to *Trichophyton simii* in India and several other countries and on occurrence of this dermatophyte in soil in India and Côte d'Ivoire as described below under different sections.

Endemicity of *T. simii* in the United States

The first case of human infection due to *T. simii* in the United States was reported by Rippon[11] in a 25-year-old female Caucasian student presenting with an erythematous scaly on the right forearm, eight weeks after her return from four-and-a-half month stay in India. Later, the first indigenous case of *T. simii* infection was a 40-year-old Nigerian male student[12] who had not been out of the United States for more than three years and had never been to India or had contact with animals or poultry.

Endemicity of *T. simii* in South America

The dermatophyte was recovered from the hair and skin of alopecic lesions in nine "Cebus apella" monkeys in the colony of the animals in the province of Corrientes, Argentina;[13] later in summer the lesions on dorsal regions spread from head to base of the tail of the animals. No human cases were detected. This monkey is found in East of the Andes from Columbia and Venezuela to Paraguay to Northern Argentina. Possibly this dermatophyte is also endemic in Columbia and Paraguay.[14] No case of human infection due to this dermatophyte is known from these countries. The "Cebus apella" monkeys are also distributed along Northern America, but infection of these monkeys due to *T. simii* has not been detected in this continent.[14] The report of *T. simii* infection in a 20-year-old female form Santa Maria, Rio Grande du sul, Brazil[15] constitutes the first autochthonous case of human infection due to this dermatophyte from South America; she had an erythematous plaque like lesion with multiple little nummular elevations small crusts and vesicles on its superior border. Neither of the patient's parents nor any one of her nine siblings and any of the domestic animals, viz dogs, cats, chickens, pigs, horses, and dairy cows in their farm had infection due to this dermatophyte.[15]

Endemicity of *T. simii* in Europe

Trichophyton simii was also recovered from circinate lesions in the leg of one patient in France.[10] *Trichophyton simii* infection was described in three cases of onychomycosis one each in Anwerpen, and Chatelet in Belgium and in one case with lesions on the neck in Anwerpen (Belgium).[10] The dermatophyte was also isolated from a pullover used by one of the patients.[10] The EMBL/GENBANK numbers are mentioned in the publication.[10] There have been no other reports of *T. simii* infection from Europe.

Epidemiology of *T. simii* in Middle East

Iran: There is only one known case of *T. simii* infection from Iran, a 9-month-old female child had extensive erythematous lesions of tinea corporis.[16] Species identification was done by sequencing of the internal transcribed spacer regions (ITS1 and ITS2) of the ribosomal DNA (rDNA) gene of the isolate.[16]

Iraq: There are two known cases of tinea manuum caused by *T. simii* in 2 females aged 22 and 23 years.[17]

Saudi Arabia: In a study from Saudi Arabia, out of 237 culturally proven cases of dermatophytosis, there was only one case of *T. simii* infection in adult male with inflammatory lesions on the scalp (tinea capitis);[18] other agents of time capitis were *M. canis* (82.3%), *M. aoudouinii* (2.2%), *T. violaceum* (13.9%). *T. mentagrophytes* (0.04%).[18] Subsequently there has been no report of *T. simii* infection from Saudi Arabia.

Endemicity of *T. simii* in Asia

India: The first report of human infections due to *T. simii* was by Gugnani et al.[19] Later, Tewari[20] isolated *T. simii* from clinically infected chickens and dogs for the first time in India. Subsequently there have been several reports of infections caused by dermatogphytes in humans and animals from different parts of India. The data of all the human cases caused by *T. simii* in India to-date is summarized in Table 1, while Table 2 summarizes the reports of animal infections due to this dermatophyte from India and other countries.

Sri Lanka: Attapattu in a study[21] of 462 patients found 106 cases of tinea capitis mostly aged 6–20 years over a period of 10 years (1967–1987); three of them (aged 6–10 years) had inflammatory lesions due to *T. simii*. There is no subsequent report of this dermatophyte from Sri Lanka.

Japan: Okoshi et al in 1966[22] reported that in a captive Chimpanzee (*Pan satyrus*) born in Africa had ringworms due to *T. simii* since its arrival in 1962 in Ueno Zoological Garden, Tokyo, Japan. The isolate was identified by Dr L.K. George at CDC, Atlanta, GA, USA.

Zoonotic transmission of *T. simii*

There are only a few instances known of transmission of *T. simii* from clinically infected animals to man. In an epizootic of *T. simii* infection involving 70 birds in a poultry farm in south-western Delhi (India), a 24-year-old male attendant showed a crusted lesion on the abdomen near the waistline;[7] the skins scrapings from the lesion were positive for fungal element by direct microscopy and culture of *T. simii*.

Familial infection due to *T. simii*

The first known report of familial infection due to *T. simii* was from Delhi in North India by Mulay and Garg[23] in one-month-old baby girl; two male children in the age group of 1–9 years in the same family had tinea capitis due to this dermatophyte. Familial infection due to *T. simii* was reported in two families from Chennai in South India by Kamalam and Thambiah,[24] all the members within 5 days in one family and 6 of the 7 members within 18 days in the second family were infected**.** Details of lesions are mentioned in Table 1.

Prevalence of *T. simii* infection in humans and animals and occurrence of this dermatophyte in soil in India and other countries

The data on the human infections caused by *T. simii* in India to-date is summarized in Table 1, while Table 2 summarizes the reports of animal infections due to this dermatophyte from India and other countries. The reports of carriage of *T. simii* by domestic animals and rodents are not included in Table 2, these are appropriately cited in the text and listed under References. Table 3 lists the reports of occurrence of *T. simii* in soil in different countries.

Table 1: Reports of dermatophytosis in humans due to *T. simii* in India.

Reference	Location/ Country	No. or % positive for dermatophytes according to species	Type of infection in *T. simii* with A/S if known, and no positive for *T. simi*	Total (percent) positive for *T. simii*
Stockdale et al.[5]	Mathura (UP), India	One	Details of lesion and treatment not known	Not applicable
Gugnani et al.[19]	Delhi, India	312: *T. rub*. – 256, *T. ment* – 23, *T. simii* – 10, *T. viol.* – 2, *T. tons* – 1, *E. flocc* – 10, *M. gypseum*. – 1	*Tinea corporis* – 7 *Tinea capitis* – 3 *T. simi* – 10. Lesions erythematous, inflammatory, *T. corporis* treated with topical clotrimazole cream. *T. capitis* with oral griseofulvin	10(3.2)

(*Continued*)

Table 1: (*Contd.*)

Reference	Location/ Country	No. or % positive for dermatophytes according to species	Type of infection in *T. simii* with A/S if known, and no positive for *T. simi*	Total (percent) positive for *T. simii*
Klokke and Durairaj[25]	Vellore (Tamil Nadu), India	471: *T. rub* – 163, *T. ment. var. inter* – 56, *T. ment. var. ment* – 3, *T. viol*. – 153. *T. tons*. – 48, *E. flocc.* – 44, *T. simii* – 4	*Tinea corporis* – 4 Positive for *T. simi* – 4. Scaly erythematous lesions, in 2 cases, the lesions were pustular, nummular, and infiltrated	4(0.85)
Tewari[20]	Mathura (UP) India	*T. simii* – 1	Nail infection	NA
Mulay and Garg[23]	Delhi, India	*T. rub*. – 1001, *T. ment*. – 39, *T. simii* – 30, *T. tons* – 11, *T. viol* – 5, *E. flocc*. – 37, *M. gypseum* – 1	Out of 30 T. *simii* cases, T. cap. – one-month-old F, *T. cap*. – 2, *T. corp*. & *T. cruris* – 3 each in 10–19-year-old M & in 3 adults, *T. pedis* in 2 M adults, *T. barbe* –1. Lesions in *T. corporis* were single or multiple, dry, scaly, circular or circinate, mostly flat. hyperpigmented and moderately to severely itching. In *T. pedis*, lesions were macerated in between the toes and dyskeratotic on the plantar surface of feet. *T. capitis* and *T. barbae* lesions occurred as single boggy and raised kerion.	30(2.67)
Mohapatra and Mahajan[26]	Delhi, India	*T. simii* – 9	*T. corporis*. – 6 with scaly, itchy, pustular lesions, *T. cruris* – 2 with scaly pustular lesions, *T. cap*. – 1 with alopic inflammatory lesion	9(?)
Thammayya and Sanyal[8]	Kolkata (West Bengal), India	18501 (in the period 1961–1987). *T. ment* – 0.90, *T. rubrum* –74.31, *T. ment. var. erinacei* – 0.9, *T. simii* – 3 interdigitale – 0.01, *T. viol*. –0.16%, *T. tons*. –0.01, *T. simii* – 0.08%, *T. megninii* – 0.03%, *T. schoen*. –0.01%, *T. vanbreuseghemii* – 0.01%, *T. verr*. – 0.0%1, *T. terestre* – 0.01%, *E. flocc*. – 2.9%, *M. gyp*. –0.15%, *M. ful*. –0.03%, *M. nanum*. – 0.01%, *M. ferrug*. – 0.01% *T. simii* – (0.01%) – 3	Details of 3 cases of *T. simii* one two-and-half-year. female child had dry scaly, erythematous lesion with raised papulovesicular margin. The 2nd one, a 22-year-old male had extensive, papular, marginated lesions on the buttocks. The third, a 38-year-old female had shiny, papular, erythematous lesions with painful nodules on the scalp	14(0.08%)
Kamalam and Thambiah[24]	Chennai (Tamil Nadu), India	All members in one family and 6 of the 7 members in the other family had *T. simii* infection	Single-to-multiple inflamed eczematous skin plaques were seen on exposed parts of the body, particularly the forearms with frequent hair infection requiring oral griseofulvin	Not known

(*Continued*)

Table 1. (*Contd.*)

Reference	Location/ Country	No. or % positive for dermatophytes according to species	Type of infection in *T. simii* with A/S if known, and no positive for *T. simi*	Total (percent) positive for *T. simii*
Kannan et al.[27]		51: *T. rub.* – 21 including 17 from skin, 2 each from nails and scalp, *T. ment.* – 4 from skin, *T. simii* – 3 from scalp, *T. viol.* – 1 from skin, *E. flocc.* – 2 from skin	Details of lesions not described in the publication	3(9.38)

Abbreviations: *T.-Trichophyton*; rub. – rubrum; gyps. – *gypseum*; fulv. – *fulvum*; ferrug. – *ferrugineum*; ment. – *mentagrophytes*, viol. – *violaceum*; tons. – *tonurans*; schoen. – *shoenleinii*; E. – *Epidermophyton*; flocc. – *flocossum*; M. – *Microsporum*; T. – cap. – *capits*; corp. – *corporis*; NA – Not applicable

Table 2: Published reports of *T. simii* infections in animals in India and other countries.

Reference	Location/Country	Number of animals with clinical lesions due to *T. simii*	Sites infected	Total no examined – no (percent)positive for *T. simii*
Pinoy[3]	India (infection detected in France)	Monkey – 1	Not known	NA
Emmons[4]	India (infection detected in the USA)	Monkey – 1	Not known	NA
Stockdale et al.[5]	Mathura (Uttar Pradesh), India	Chickens – 27, dog – 1		
Okoshi[22]	Kenya (infection detected in Japan after import of the animal in the zoo in Tokyo)	Chimpanzee – 1	The lesions were circular, alopecic with thin grey to white crusts on all parts of the hairy skin of the body	NA
Tewari[20]	India	Chickens and dogs. Number of infected not known	Not known	Not known
Gugnani et al.[7]	Delhi, India	70 poultry birds out of flock of 250 examined infected with *T. simii* 7 birds in one additional and 2 birds in two other poultry farms	Comb, wattle, and basal portion of the flank feathers. In 8 birds, entire combs heavily infected, scaly and erythematous with a ragged appearance Scaly erythematous lesions on the combs	70/250(28) Not known
Gugnani et al.[7]	Hisar (Haryana), India	3 poultry birds with *T. simii*	Scaly erythematous lesions on flank feathers	Not known
Gugnani et al.[7]	Meerut (Uttar Pradesh), India	3 poultry birds with *T. simii*	Scaly erythematous lesions on flank feathers	Not known
Ranganathan et al.[28]	Chennai (Tamil Nadu) India	Two of 89 dogs with dermato- phytic infection had lesions due to *T. simii*	Lesions were scaly, circinate with defined margin with minimal or no crusts. No mention of treatment.	211–2(0.95)

(*Continued*)

Table 2: (*Contd.*)

Reference	Location/Country	Number of animals with clinical lesions due to *T. simii*	Sites infected	Total no examined – no (percent)positive for *T. simii*
Mitra[29]	Several locations in Uttar Pradesh (India)	5 of 22 cattle infected with dermatophytes, *T. simii* – 1	Details of lesions not mentioned	22–1(4.5)
Gugnani[30]	Delhi, India	2 dogs with scaly erythematous	Skin lesions on the body	Not known
Boehringer et al.[10]	Corrientes, Argentina	4 of 9 Cebus apella' monkeys infected with *T. simii* in an outbreak	Alopecic lesions on dorsal regions from head to base of the tail	9–4(44.4)

Table 3: Occurrence of *T. simii* in soil in India and in Ivory Coast.

Reference	Location/Country	Soil type - number of samples. exam.	Number of positive for *T. simii*	Total number of samples exam. (% positive for *T. simii*)
Gugnani et al.[31]	Delhi-several localities/India	Grasslands – 50, Pastures – 50, Rodent burrows – 48, fowl habitats – 46, Cattle yards – 45, Gardens – 43	22 (majority of positive samples being from pastures)	287(7.67)
Padhye and Thirumalachar[32]	Pune/India	Poultry farm – 15	7	15(46.67)
Beguin et al.[10]	Abidjan/Ivory Coast	?	1	?

DISCUSSION

Trichophyton. simii infection until recently considered to be confined to specific endemic areas has been reported in several countries in different continents as shown in this study. *T. simii* appears to be primarily a zoophilic dermatophyte in view of its more frequent and consistent association with the fur of *Tatera indica* (The Indian Gerbil), a predominant field rodent and *Suncus murinus,* a common shrew found in the wild and rural areas of North India (Gugnani, 1970).[31] In another survey, several other species of rodents, viz. *Rattus rattus*, *R. norvegicus*, *Mus musculus* commonly inhabiting houses were found to be carriers of *T. simii* (Gugnani et al.).[33] Other animal hosts are poultry, and domestic animals including dogs, and bovines (Gugnani and Randhawa 1973;[7] Ranganathan et al. 1997[28]). All these animal hosts and soil can be the source of human infections. *Trichophyton simii* can infect several body sites and scalp in humans.[8,17,23] Literature review has established that *T. simii* is primarily a zoophilic dermatophyte that also occurs frequently as a geophilic species; human infections can be acquired from animals[7] and soil,[9] and occasionally from fomites, e.g. pullover.[10] Reverse transmission of *T. simii* infection from animals to man is also known.[34] Prior to this report, reverse transmission of *M. gypsum* infection from man to dog was reported.[35] The extent of reverse transmission of *T. simii* infection from humans to animals is not known and needs to be explored. It may be recorded here that *T. simii* infections in humans have been reported from some countries in Europe, viz. Belgium, France,[10] and in the Middle east, viz. Iran[16] and Iraq,[17] Saudi Arabia,[18] though there are no reports of animal infections due to T. *simii* in these countries, or of occurrence of this dermatophyte in soil of these countries. This emphasizes the need for investigating the epidemiology of *T. simii* infections in the countries.

A rapid and sensitive real-time PCR assay based on internal transcribed sequences developed by Bergman et al.[36] allows the rapid detection and identification of eleven clinically relevant species within the three genera of dermatophyte, viz. *Trichophyton*, *Microsporum,* and *Epidermophyton* in nail, skin, and hair samples within a few hours as compared to conventional culture technique which takes 2–4 weeks. In view of the scarcity of reports of isolation of *T. simii* from soil, a PCR technique based on genomic sequence following the method of Bergman et al.[36] should be developed

to explore geophilic occurrence of this dermatophyte in countries from where human and animal infections caused by it have been reported. In conclusion, it can be said that *T. simii* infections in humans and animals though formerly known to be restricted to specific endemic regions, now appear to be frequent in non-endemic areas. Comprehensive surveys of infection in humans and animals employing mycological culture and latest molecular techniques, namely automated DNA extraction and real-time PCR,[36] and sequencing of ITS1 and ITS2 of the ribosomal DNA[17] are needed to estimate the true prevalence of *T. simii* infections in different countries.

Declaration of patient consent

Patient's consent not required as there are no patients in this study.

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Conflicts of interest

There are no conflicts of interest.

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