Outbreaks And Epidemics Of Superficial Dermatophytosis Due To Trichophyton mentagrophytes Complex And Microsporum canis: Global And Indian Scenario

Abstract: Until recently, superficial dermatophytosis, also known as tinea, was considered as a minor skin infection, which was easy to treat. There used to be rare outbreaks and epidemics of superficial dermatophytosis. Lately, there is a sweeping change in the clinical presentation due to extensive, atypical and recalcitrant dermatophytosis. Treating such infections poses a great challenge to the clinicians. Dermatophytosis is a superficial fungal infection of keratinized tissue (skin, hairs and nails) by dermatophytes (fungus). It is caused by the three genera of dermatophytes: Trichophyton, Epidermophyton and Microsporum. The conventional methods of laboratory diagnosis have now been substantiated by molecular characterization. Earlier epidemics were usually due to anthropophilic dermatophytes. Now, zoophilic dermatophytes are also responsible for many outbreaks and epidemics. We need to be equipped with the tools to face the current scenario, because this depends upon the competence of the staff working in the state-of-the-art laboratories, which is needed for the study of the epidemiology and appropriate treatment.

Keywords: Trichophyton mentagrophytes (T. mentagrophytes), Microsporum canis (M. canis), epidemic, outbreak

Introduction
Dermatophytes are fungi that have the ability to invade keratinized tissue such as skin, hair and nails and thus are the main cause of mycoses of the integument in humans and animals. Classification of dermatophytes is being updated as the new species are evolving. According to the new classification of dermatophytes by de Hoog et al, dermatophyte species have been grouped into seven genera: Trichophyton, Epidermophyton, Arthroderma, Nannizzia, Microsporum, Paraphyton and Lophophyton and this taxonomy of dermatophytes includes 16 species of Trichophyton, one species of Epidermophyton, 9 species of Nannizzia, 3 species of Microsporum, one species of Lophophyton, 21 species of Arthroderma and one species of Ctenomyces. Epidemics and outbreaks due to dermatophytes have been reported in the literature from time to time. Large-scale epidemic of inflammatory dermatophytosis due to Trichophyton mentagrophytes var. mentagrophytes occurred among American troops in Vietnam during 1966–1969. The source of this epidemic was traced to the rats trapped near the army living quarters.
Among the recent epidemics and outbreaks are: *T. mentagrophytes* genotype VIII in India, which has been reported by Nenoff et al.⁶ and two articles have mentioned genital infection due to *T. mentagrophytes* genotype VII from Switzerland and Germany.⁷,⁸ Also, an outbreak due to *M. canis* and with human-to-human transmission has been stated in Israel.⁹

As cited by Rippon JW (1985) in one of his papers titled “The changing epidemiology and emerging patterns of dermatophytes species” the only evidence of active evolution among the dermatophytes is seen in *M. canis* and *T. mentagrophytes*. In both, host-specific strains have emerged and will probably separate as species. This probably has happened already in the case of the variety interdigitale of *T. mentagrophytes*.¹⁰

Now, we see that it holds true and it has actually happened even before we realized. The zoophilic species like *M. canis* and *T. mentagrophytes* can infect virtually every mammal.¹¹

### Current Epidemics

The current epidemics over different geographical regions of the world are due to *T. mentagrophytes* complex and *M. canis*. Until recently, it was thought that the anthropophilic species are responsible for most of the epidemics, but sometimes humans infected by zoophiles remain contagious, leading to small, self-limiting outbreaks and epidemics.⁴,⁶ In some of the outbreaks, person-to-person (anthropophilic) transmission has been implicated either through direct contact or through contaminated fomites.⁴,¹²–¹⁴

### Confusion Due To Frequent Changes In The Nomenclature Of *Trichophyton mentagrophytes* Complex

There have been frequent changes in the nomenclature of *T. mentagrophytes* complex. The anthropophilic form was known as *Trichophyton mentagrophytes* var. interdigitale and zoophilic form as *T. mentagrophytes* var. *mentagrophytes*.¹¹ Later, *Trichophyton interdigitale* (anthropophilic strains) and *Trichophyton interdigitale* (zoophilic strains)¹⁵ *Trichophyton mentagrophytes* complex has been divided into *Trichophyton mentagrophytes* containing eight genotypes, which are zoophilic, and two genotypes of *Trichophyton interdigitale* (anthropophilic species)¹⁶,¹⁷ (Table 1). Polymerase Chain Reaction (PCR) cannot differentiate the two species, but it is possible with sequencing of the internal transcribed spacer (ITS) of fungal DNA.⁶ Even in many journals, the nomenclature of *T. mentagrophytes* and *T. interdigitale* has been used interchangeably. So, the actual prevalence of these two closely related species is not known. Molecular typing of dermatophytes is available in very few laboratories all over the world.

### Microsporum canis Complex

*M. canis* has retained teleomorphs (teleomorph or sexual states) (Figures 1 and 2). It has been found that the distribution of the two compatible mating types is of little importance for propagation and survival in these two species.¹¹ Most of

| Table 1 | *Trichophyton Menagrophytes Complex*. Nomenclature (Old And Current) |
|---------|---------------------------------------------------------------------|
| Author  | Anthropophilic                                      | Zoophilic                                         |
| Kwon-Chung et al.¹¹ 1992 | *Trichophyton mentagrophytes var. interdigitale* | *Trichophyton mentagrophytes var. mentagrophytes* |
| Nenoff et al.¹⁵ 2007 | *Trichophyton interdigitale* (anthropophilic strains) | *Trichophyton interdigitale* (zoophilic strains) |
| Heidemann et al.¹⁶ 2010 Ninet et al.¹⁷ 2003 | Current ITS-based genotypes of *Trichophyton mentagrophytes complex* | *Trichophyton mentagrophytes* (zoophilic genotypes) genotype I & II |
|            | *Trichophyton interdigitale* (anthropophilic genotypes) genotype III–VIII |

Figure 1. *M. canis*: Whitish fluffy and fur-like surface having yellow pigment at the periphery.
the isolates of *M. canis* throughout the world are known to be the (−) type of *Arthroderma otae*. The positive (+) type was found to be in a ratio of 113 (−) to 1 (+) in Japan, but was not found elsewhere. It is possible that one mating type had selective advantage while the other mating type died out in the process of geophilic to zoophilic evolution.

Person-to-person transmission has been recently reported in Israel.

### Indian Scenario

India had been facing a challenging scenario of recurrent, extensive and recalcitrant superficial dermatophytosis due to *T. mentagrophytes* genotype VIII. *T. mentagrophytes* complex consists of several ana-morphs and three teleomorphs (*Arthroderma vanbreuseghemii*, *A. benhamiae* and *A. simii*) and are usually isolated from pets, such as guinea pigs and rabbits.

India has recently witnessed a change in the epidemiology of dermatophytes. Earlier, *Trichophyton rubrum* was found to be the predominant species. During the past four-five years, *T. mentagrophytes* (Figures 3 and 4) is showing a rising trend in several states of North India (Table 2). In this table, the nomenclature *Trichophyton interdigitale* and *T. mentagrophytes* have been used interchangeably except in Chandigarh and Delhi, where molecular typing was done. Due to reasons unexplored, the prevalence of dermatophytosis due to *M. canis* is less prevalent in India (0.76–4.5%) (Table 2).

In India, very few people keep pets due to various reasons like poor economic status, small houses and rarely cultural issues, though there are many stray dogs of mixed breed. So, the prevalence of *M. canis* could be less in India. There are lots of rodents, stray animals and monkeys, which could be possibly associated as a source or the agents for the spread of *T. mentagrophytes* infection. Also, many people dry their clothes and bed linen/bedding outside their houses, and there is every possibility of the clothes and linen getting contaminated either directly or indirectly from the environment.

There could be some genetic factors, because the first author (R. Thakur) had extensive experience in dermatophytosis in Botswana (Africa) and India and has not reported even a single case of dermatophytosis due to *M. canis* from the areas where she worked. *M. canis* is widespread worldwide.

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**Figure 2** *M. canis*: LPCB mount showing septate hyphae with thick-walled spindle-shaped macro-conidia and slightly curved tip.

**Figure 3** Growth of *T. mentagrophytes* on SDA after 7 days of incubation. Powdery to fluffy cottony, cream to white on obverse and beige to brown on reverse.

**Figure 4** *T. mentagrophytes*: LPCB mount showing septate fungal hyphae, with numerous spherical micro-conidia arranged in grape-like clusters, cigar-shaped macro-conidia and spiral hyphae.
| Authors, Year And Place Of Study | Predominant Species | Second Predominant Species | Other Dermatophytes |
|----------------------------------|---------------------|---------------------------|--------------------|
| Thakur et al 2018, Muzaffarnagar, Uttar Pradesh | T. interdigitale 98% (confirmed to be T. mentagrophytes genotype VIII) | T. rubrum & T. violaceum 1% | |
| Rudramurthy et al 2018, Chandigarh | T. interdigitale 66.1% | T. rubrum 26.3% | T. tonsurans 3% M. canis 1.5% |
| Singh et al 2018, Delhi | T. interdigitale 94% | T. rubrum 3% | T. tonsurans 1.5% T. violaceum 1.5% |
| Narain et al 2018, Allahabad, Uttar Pradesh | T. mentagrophytes 52.47% | T. rubrum 34.98% | T. violaceum 3.80% T. verrucosum 1.52% M. canis 0.76% E. floccosum 0.76% |
| Vineetha et al 2018, Kerala | T. rubrum 45% | T. mentagrophytes 18% | T. tonsurans 2% |
| Mahajan et al 2017, Banaras | T. mentagrophytes 75.9% | T. rubrum 21.9% | T. tonsurans 0.7% |
| Sharma et al 2017, Sikkim | T. mentagrophytes 40% | T. schoenleinii 33.3% | T. tonsurans 16.6% T. rubrum 6.6% E. floccosum 3.33% |
| Verma et al 2017, Shimla, H.P. | T. mentagrophytes 62.28% | T. rubrum 23.40% | T. violaceum 6.85% T. tonsurans 2.85% |
| Dabas et al 2017, New Delhi | T. interdigitale 56% | T. rubrum 7.5% | |
| Kansra et al 2016, Amritsar, Punjab | T. mentagrophytes 46.43% | T. rubrum 24.29% | T. verrucosum 12.14% T. schoenleinii 11.43% T. violaceum 3.57% M. gypseum 2.14% |
| Pathania et al 2017, Chandigarh | T. mentagrophytes 40% | T. rubrum 32.2% | T. interdigitale 11.1% |
| Noronha et al 2016, North Karnataka | T. mentagrophytes 48.3% | T. rubrum 38.3% | T. verrucosum 8.3% T. violaceum 5% |
| Putta et al 2016, Kolhapur, Maharashtra | T. mentagrophytes 37.74% | T. tonsurans 28.30% | T. rubrum 24.53% |
| Penmetcha et al 2016, Guntur, Andhra Pradesh | T. rubrum 37.64% | T. mentagrophytes 30.58% | T. violaceum 7.05% T. tonsurans 0.5% T. verrucosum 7.05% T. schoenleinii 2.35% E. floccosum 4.75% M. audouinii 3.53% |
| Choudhary & Kumar 2016, Bihar | T. rubrum 62.3% | T. mentagrophytes 14.1% | E. floccosum 7.05% T. schoenleinii 3.5% |
| Poluri 2015, Telangana | T. rubrum 58.06% | T. mentagrophytes 22.58% | |
| Lakshmanan et al 2015, Tamil Nadu | T. rubrum 79% | T. mentagrophytes 14.5% | M. canis 3.2% M. gypseum 3.2% |
| Naglot et al 2015, Assam (Northeast India) | T. rubrum 50.15% | T. mentagrophytes 29.2% | E. floccosum 9.84% |
| Najotra et al 2015, Samba, Jammu & Kashmir | T. rubrum 41.8% | T. tonsurans 22.4% | T. mentagrophytes 10.5% T. violaceum 7.5% T. schoenleinii 5.9% M. gypseum 4.5% M. canis 4.5% E. floccosum 2.9% |
(particularly in Europe, the eastern Mediterranean and South America) and plays an important zoonotic role. Most of the infections have been reported from the countries with predominance of Caucasians.

**Conclusion**

Identification of the dermatophyte is important for the sake of appropriate treatment, prevention and epidemiology. Conventional methods may not be adequate for the differentiation of *T. mentagrophytes, T. interdigitale* and *T. benhamiae*, because there are not many characteristics distinguishing microscopic features. Some of these zoophilic dermatophytes, e.g. *T. mentagrophytes* (genotype VIII) and *T. mentagrophytes* (genotype VII) and *M. canis* can also have anthropophilic mode of transmission. Also, unusual infection like tinea genitalis has been reported due to *T. mentagrophytes* (genotype VII) and *M. canis*. Recently, dermatophytosis due to *T. interdigitale* genotype I and *Trichophyton mentagrophytes* genotypes V and VIII were reported from Iran. But, genotype VIII has not acquired the epidemic proportions like India. In another study in North of Iran, molecular characterization of the dermatophytes was done using polymerase chain reaction-restriction fragment length polymorphism (PCR-RFLP) on the ribosomal DNA internal transcribed spacer (ITS) region; *Trichophyton interdigitale* was found to be the predominant species and responsible for most of the cases of tinea pedis and next in frequency to *T. rubrum* for causing tinea unguium. The results of dermatophyte species identification with ITS-RFLP showed 100% concordance with the sequencing results for the ITS of the regions of rDNA.

Many outbreaks of tinea capitis due to anthropophilic dermatophytes, e.g. *Trichophyton tonsurans*, *Trichophyton violaceum* and *Trichophyton audouinii* have been reported earlier. In one of the studies, by Allahadadi et al in Arak city, centre of Iran, *T. tonsurans* was the predominant species isolated from asymptomatic carriers. Infection due to *T. tonsurans* at times does not resolve at puberty.

So, a precise identification and delineation of isolates at species and strain level is crucial to settle effective programs for controlling and preventing infection and to establish accurate antifungal therapies. Since dermatophytosis has public health importance, an appropriate diagnosis, source of infection and treatment are very crucial.

**Disclosure**

The authors report no conflicts of interest in this work.

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