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Ecology and epidemiology of dermatophyte infections

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Our knowledge of ecology and epidemiology of dermatophytes and the factors influencing their transmission has helped us understand better the natural history of dermatophytoses. It seems that the anthropophilic agents of scalp infection are being eradicated in developing nations. The exception is *Trichophyton tonsurans*–related tinea capitis in North America. *Microsporum canis* is a prevalent agent of tinea capitis in many regions of the world, and this could be related to close association of humans with their pets. *Trichophyton violaceum* is endemic in certain parts of Eastern Europe, Africa, Asia, and South America but not in North America. *Trichophyton rubrum* is the most common cause worldwide of tinea pedis, nail infection, tinea cruris, and tinea corporis. Although the incidence of tinea capitis is declining in developed nations, tinea pedis and onychomycosis are becoming more common. The increased use of athletic shoes both by men and women and communal bathing could be contributing factors. Five or six species account for most dermatophytoses globally. (J AM ACAD DERMATOL 1994;31:S21-S25.)

The causes of dermatophytoses are classified into three anomorphic genera, *Trichophyton, Microsporum*, and *Epidermophyton*, depending on their conidial structures. Teleomorphic dermatophytes are classified into one genus, *Arthroderma*. Approximately 40 species are in the anomorphic genera: 22 species of *Trichophyton*, 16 of *Microsporum*, and two of *Epidermophyton*.

ECOLOGIC CLASSIFICATION

Dermatophytes are frequently divided into three major groups on the basis of their natural habitat and host preferences: (1) geophilic or soil-inhabiting fungi, which occasionally can be pathogenic for humans or animals; (2) zoophilic species, which prefer animals as hosts but also can infect humans; and (3) anthropophilic species, which are typically human pathogens (Table I).

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The dermatophytes basically are soil saprophytes that have acquired the ability to digest keratinous debris in soil, thus becoming "keratinophilic fungi." A few of these organisms gradually evolved to parasitize keratinous tissues of animals living in close proximity with soil, such as *Microsporum nanum* in pigs and *Trichophyton quickeanum* in mice. The other keratinophilic soil fungi, *Chrysosporium keratinophilum* and *Trichophyton terrestre*, for instance, failed to parasitize human or animal keratin and remained the link between geophilic dermatophytes and nonkeratinophilic soil fungi. Some of these dermatophytes, adapting to cornified substrate in living animals, became zoophilic and lost their ability to survive in soil. *Microsporum canis* var *distortum* (a zoophilic species) survives for only a short period when experimentally inoculated into soil.[1]

Anthropophilic dermatophytes are believed to have evolved from zoophilic fungi.[2] According to this view, some zoophilic dermatophytes adapted to human keratin while losing their ability to digest animal keratin. The selectivity of *Microsporum audouinii* and *Trichophyton rubrum* may have developed in this way because they rarely infect animals.

Table III. Main causal agents for tinea capitis in different geographic areas

Europe	N. America	Africa	Pakistan/India	S. America
M. canis	*T. tonsurans* *M. canis* *M. audouinii*	*T. violaceum* *T. soudanense* *M. audouinii* *M. canis* *T. yaoundei*	*T. violaceum*	*T. violaceum* *M. canis*

rubrum. Data can be validated when the clinical origin of isolated dermatophytes is taken into consideration (Table II). In a 20-year survey of the Chicago area, Bronson et al.[4] reported an epidemic of infection with *Trichophyton tonsurans*. From 1976 to 1980, 96% of tinea capitis and 76% of tinea corporis infections were caused by this fungus. The increase in the number of cases of tinea corporis caused by *T. tonsurans* has paralleled that seen in tinea capitis. Women outnumbered men in a ratio of nearly six to one. The high prevalence in women of childbearing age may be from their frequent contact with infected children. Another important finding in this study was that prepubertal infection with *T. tonsurans* does not always resolve at puberty, as do infections with *Microsporum* species.

Tinea capitis is a classic example of the changing geographic patterns of dermatophytosis in Western Europe and much of the rest of the world. *Microsporum audouinii* and *M. canis* were the causes of scalp infection in the late nineteenth and early twentieth centuries in Western and Mediterranean Europe. In Eastern Europe, *T. schoenleinii* was the predominant cause of the favus type of tinea capitis.[5, 6] Presently tinea capitis has been disappearing in Western Europe. This decrease has lead to a reduction in infection from the four anthropophilic species in this location (*M. audouinii, T. tonsurans, T. violaceum,* and *T. schoenleinii*).[7] Sporadic cases of tinea capitis still occur but are usually caused by *M. canis*.[6] *T. violaceum* is now the predominant agent of scalp infections in Eastern Europe. In the Mediterranean, the incidence of *M. canis* infection has been rising steeply in recent years. In Italy and Slovenia (Yugoslavia), *M. canis* is the most frequently isolated dermatophyte[8] in tinea capitis.

In the United States, *M. audouinii* and *M. canis*, once the major agents of tinea capitis, have been superseded by *T. tonsurans*. Since the 1950s, *T. tonsurans* has advanced from Mexico and the Caribbean and is now the prevalent cause of tinea capitis in North America.[4, 9, 10] The epidemiology of tinea capitis from *T. tonsurans* has been studied on several occasions.[11, 12] Infections from *T. tonsurans* are transmitted directly or indirectly from person to person. Mackenzie[13] studied an outbreak of *T. tonsurans* in a residential school and recovered the fungus not only from infected children but also from hairbrushes, combs, pillowcases, other bedding materials, and even dormitory floors.

In Africa large-scale epidemics of tinea capitis are associated with *Trichophyton soudanense, T. violaceum, T. schoenleinii, Microsporum ferrugineum,* and *M. audouinii* (Table III).[14] Infections with *T. tonsurans* and *T. mentagrophytes* are widely distributed but are not common. Certain anthropophilic species (*Trichophyton soudanense, T. yaoundei,* and *T. gourvilii*) remain geographically restricted. There are no established endemic foci in the neighboring regions.[14] *T. soudanense* has been regularly introduced into Britain by Africans and yet the local population rarely became infected. *Trichophyton megninii* is found mainly in North Africa and sporadically in Portugal, Spain, and Sardinia. In Portugal it accounts for about 4% of dermatophytes isolated from scalp and glabrous skin.[15] Other geographically restricted dermatophytes are *T. yaoundei* in Cameroon, Africa, *T. concentricum* in the Western Pacific, Malaysia, and Central and South America, and *T. schoenleinii* in the Appalachian Mountains of the United States. In Japan tinea capitis caused by *M. ferrugineum* has been virtually eradicated in recent years because of improved hygienic conditions.[16] In the Indian subcontinent and Southeast Asia, little tinea capitis exists, which has been attributed to the cosmetic use of hair oil (mustard seed oil) that may perhaps prevent or inhibit colonization by these dermatophytes.[17] *T. violaceum* is the common tinea capitis agent in these regions (Table III). In South America *M. canis* is the most common cause of scalp infection in Argentina, but *T. violaceum* is more common in Brazil and *T. tonsurans* in Peru. *M. canis* is also the main cause of tinea capitis in Australia and New Zealand, but *T. tonsurans* is endemic in the aborigines of North and Central Australia.[17]

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Current therapy of dermatophytosis

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In the past dermatophytes were treated with topical agents or, in the case of more recalcitrant or extensive disease, with oral antifungals (griseofulvin or ketoconazole). Topical therapies may be effective in many cases, but they have limitations. They may be viewed as inconvenient by the patient, thereby affecting compliance. Therapy with early oral antifungals entails long treatment periods until complete cure is obtained. For ketoconazole rare but serious side effects can occur, particularly with prolonged use. Griseofulvin is still the drug of choice for the treatment of tinea capitis of the *Microsporum* type. In recent years a few new antimycotic agents have been developed for systemic therapy of superficial fungal infections. Itraconazole is a broad-spectrum triazole. Fluconazole belongs to the same chemical class and was used mainly in systemic yeast infections and mucosal candidosis. Terbinafine is an allylamine and has been found to be effective and safe in brief therapy of dermatophyte infections. Short-duration therapy of most dermatophyte infections is also possible with itraconazole. The high and specific activity against the causative agents, together with their pharmacokinetic properties, explains the good results obtained with these new drugs and their improved safety profile. Their mode of action, pharmacokinetics, and treatment schedules will be discussed. (J AM ACAD DERMATOL 1994;31:S25-S30.)

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Fungal infections of the skin, hair, and nails are among the most common skin diseases. In recent years the incidence of these infections has been increasing steadily. Much of this increase has been attributed to the expanding number of immunocompromised patients and to lifestyle changes. The use