

The Occurrence of Keratinophilic Fungi and Related Dermatophytes from Playground Soils of Ujjain, India

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Abstract: Soil is well-known as a route to fungal infection in human. Recently, human exposure to potentially pathogenic fungi is threatening the health of people. Keratinophilic fungi and related Dermatophytes in the soil are diverse group that depend on different factors, such as vertebrates and human activity. These fungi plays vital task in decomposing debris of man and animals in nature.the present study deals with the occurrence of keratinophilic fungi and related dermatophytes from playground soils of Ujjain, India.

Key words: soil, playground, dermatophytes, keratinophilic, fungi, nature, debris, infection, pathogenic.

Introduction

Keratinophilic fungi are an ecologically important group of fungi that cycle one of the most abundant and highly stable animal proteins on earth - keratin. The biggest group of organisms that can utilize keratin as the sole source of carbon and nitrogen are the keratinophilic fungi. These are minute organisms that cannot be seen by the naked eye, unlike macrofungi like mushrooms.[1]

The word keratinophilic means 'keratin loving', and is sometimes misleading in the sense that all fungi that can grow on hair (a common natural keratin substrate) could be considered as keratinophilic. However, hair is not solely made of keratin, and many fungi that grow on natural hair do not actually utilize the keratin, but rather use the non-keratin lipid fraction of the hair. Thus only fungi which actually degrade keratin should be considered as keratinophiles or keratinolytic fungi. In the Kingdom Eumycota (true fungi), two groups - the Deuteromycetes and ,the Ascomycetes - have keratinolytic members that occur commonly in soil as keratin decomposers. Some species are potential pathogens, and can cause infections in the skin and scalp of mammals (the dermatophytes). These dermatophytes include the genera *Microsporum* and *Trichophyton*. It is thought that dermatophytes were initially saprophytic and lived in the soil, but due to increasing interactions with animals, they gradually evolved a parasitic lifestyle. The dermatophytes have been classified into three ecological groups based on their habitat preference - geophilic (soil loving), zoophilic (animal loving) and anthropophilic (human loving). Molecular studies based on the DNA sequence analysis of the ribosomal ITS region have shown that these three groups are also phylogenetically distinct.[2,3]



Fig.1. *Tinea corporis*

The term dermatophyte is a label used for three types of keratinophilic fungi responsible for the majority of fungal skin infections in humans. The three genera, *Trichophyton*, *Microsporum*, and *Epidermophyton*, together comprising about 40 different species, can be transmitted in many different ways, including person-to-person contact, contact with geophilic organisms in the soil, spread via animal vector, and even indirectly through inanimate objects carrying the fungi. Infections are primarily localized to the hair, nails, and outer layers of the skin, reflecting the affinity of the fungi for keratin and the inability of the fungi to invade deeper tissues or organs in immunocompetent skin.[4,5] Infections can cause a number of symptoms, including extensive inflammation, itching, and discolored, scaly skin lesions. Keratinophilic fungi and related Dermatophytes in the present study are isolated from playground soils of Ujjain express cell-surface associated and secreted proteins that may contribute to virulence. Coincubation of peripheral blood mononuclear cells (PBMCs) with mannan, a glycoprotein found in the fungal cell wall, inhibits lymphocyte proliferation in response to mitogens and antigenic stimuli. Additionally, these fungi express a number of proteases, including elastase and keratinases, which likely contribute to the spread of the fungi within the skin by degrading substrates in the extracellular matrix.



Fig.2. *Tinea pedis*

Treatment options for dermatophytoses depend on the location and extent of the infection. As such, topical antifungals are used to treat the majority of dermatophyte infections, although oral therapy is preferable for tinea capitis, tinea barbae, and tinea unguium.[6,7]

Dermatophytosis (ringworm or tinea) is a superficial cutaneous infection with one or more of the keratinophilic fungi that belong to the genera *Microsporum*, *Trichophyton*, or *Epidermophyton*. Transmission of Keratinophilic fungi and related Dermatophytes in the present study are isolated from playground soils of Ujjain occurs by close contact with other infected animals or through contact with contaminated fomites (which includes the haircoats of animals and arthropods such as fleas or houseflies). Keratinophilic fungi and related Dermatophytes in the present study are isolated from playground soils of Ujjain spores survive more than a year in the environment under optimal conditions of temperature and humidity, and they resist most routinely used hospital disinfectants, which facilitates transmission. [8,9] Geophilic dermatophytes are soil saprophytes. The most common geophilic dermatophyte that infects dogs or cats is *Microsporum gypseum*, which is most prevalent in warm, humid tropical and subtropical environments. Zoophilic dermatophytes are adapted to animal hosts and are rarely found in soil. The most common zoophilic dermatophyte that infects dogs and especially cats is *Microsporum canis*; this organism accounts for more than 90% of dermatophyte isolates from cats worldwide and more than 60% of isolates from dogs playing in soils of Ujjain playgrounds. [10,11]

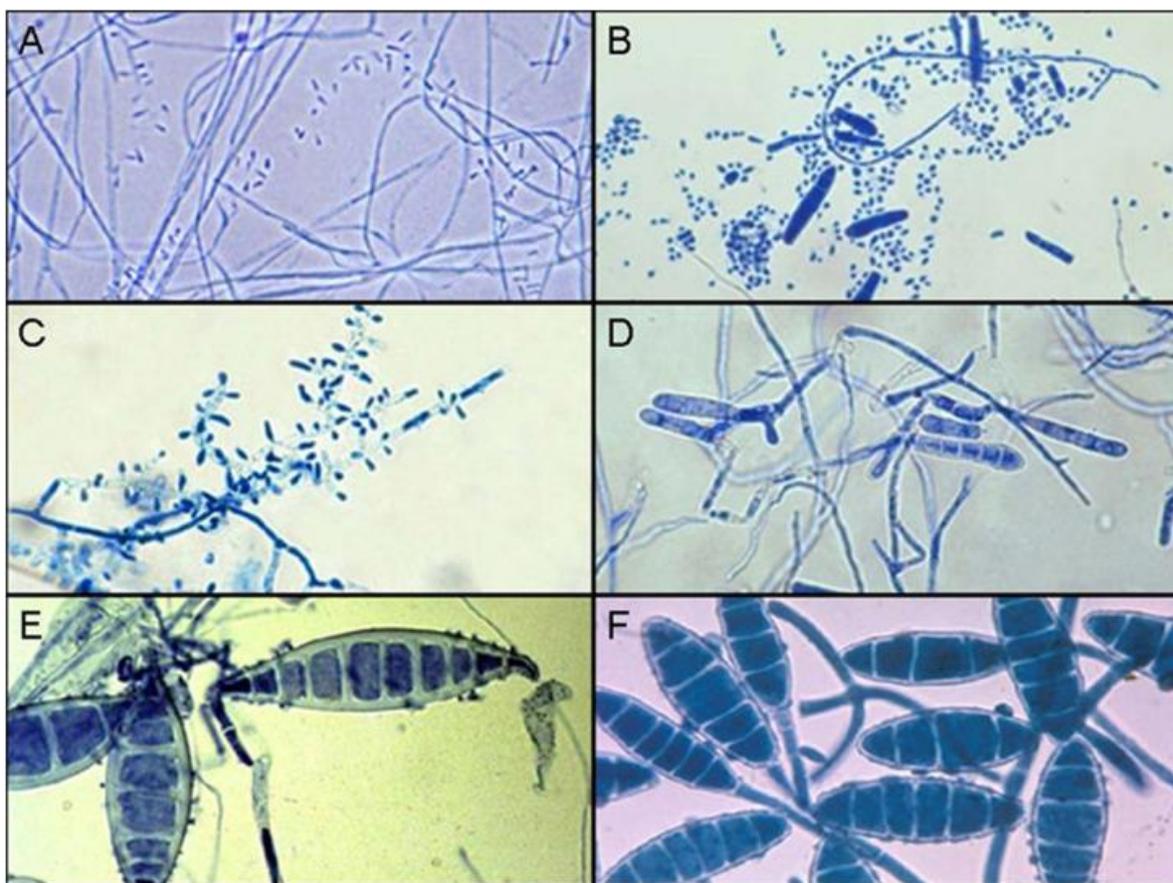


Fig. 3. Microscopic characteristics of most clinically important dermatophytes – (A) *Trichophyton rubrum*. (B) *Trichophyton mentagrophytes*. (C) *Trichophyton tonsurans*. (D) *Epidermophyton floccosum*. (E) *Microsporum canis*. (F) *Nannizzia gypsea*.

Feathers are major biological waste generated in large amount by local poultry processing industry, these industries manages feather waste either by steam or chemical treatment to produce feather meal.

Sometimes untreated forms of feathers are used as fertilizers or disposed as landfill. Biodegradation of feathers by keratinophilic fungi is found to be an efficient and cost-effective method for bioconversion of feather waste into nutritionally rich biofertilizers. Keratinophilic fungi and related Dermatophytes in the present study are isolated from playground soils of Ujjain support better degradation of feather by keratinase activities and enhance nutritional value of soil. Feather compost is rich in nutritional quality. Decomposition of feather increases availability of N and P in soil. These fungi could be a major pollution controller for leather industry because all wastes generated from leather treatment contains keratinous material.[12,13]

Discussion

Keratinophilic fungi and related Dermatophytes in the present study are isolated from playground soils of Ujjain are able to invade and degrade keratinized tissues, causing a variable inflammatory response. Anthropophilic dermatophyte species are more adapted to human tissues and usually trigger a milder inflammation when compared with zoophilic and geophilic species. Dermatophytoses are common cutaneous infections, universally distributed, affecting individuals of all ages and both sexes leading to serious chronic morbidity. Changes in frequency and epidemiologic features of the disease have been increasing due to population mobility, changes in human lifestyle, and advents of antifungal drugs. Transmission occurs through human contact with infected individuals, animals, soil, and fomites. [14,15] Epidemiology and clinical presentation varies according to the affected body site and the species of dermatophyte involved.

Dermatophytosis of the body (*tinea corporis*) affects the glabrous skin and is commonly known as ringworm. The most common agents are anthropophilic fungi, being *Trichophyton rubrum* the most common, followed by *Epidermophyton floccosum* and *Trichophyton mentagrophytes*. Clinically, the lesions present as annular plaques with central clearing, leading scale, and a ring-shape appearance.

Dermatophytosis of the face and the beard (*tinea faciei*, *tinea barbae*) are less common clinical forms. Zoophilic species are mostly implicated such as *T. mentagrophytes* but anthropophilic dermatophytes can also be involved. Usually, there is an inflammatory pustular eruption with crusts resembling bacterial folliculitis, kerion presentation can also occur. Dermatophytosis of the scalp (*tinea capitis*) is almost exclusively a disease of childhood. It occurs in poor socioeconomic conditions and involves mainly the anthropophilic species *Trichophyton tonsurans* and the zoophilic *Microsporum canis*. The former usually presents with multiple scaly alopecic patches and poor or absent inflammatory signs. The latter usually occurs as a large single alopecic patch and can be associated with a more intense inflammatory reaction. Diffuse scaling, black dots and diffuse pustular lesions can also be present.[16,17] Kerion Celsi is a clinical variant characterized by an exacerbated inflammatory response, usually misdiagnosed as bacterial infection. Late diagnosis of *Kerion celsi* can lead to permanent scarring alopecia. Dermatophytosis of the hands (*tinea manuum*) affects the palmar surface and is usually unilateral. When it presents bilaterally, it must be distinguished from contact eczema and psoriasis for correct treatment. *Tinea manuum* is quite rare. On the contrary, dermatophytosis of the feet (*tinea pedis*) is very common. The main species involved in *tinea pedis* are *T. rubrum*, *T. mentagrophytes*, and *E. floccosum*. They may affect the plantar and interdigital areas causing erythema, and thin or laminar scaling. There are three main clinical variants: the interdigital form, the vesicobullous form and the chronic squamous form. The interdigital form is the most common and presents with maceration or scales between toes, intense itching and eventually erythema and painful fissures. The chronic squamous form (moccasin-type) is clinically characterized by plantar erythema with scaling involving the lateral and plantar surfaces of the foot, and usually occurs due to anthropophilic fungi, mainly *T. rubrum*. [18,19]The vesicobullous is an inflammatory, less common form, usually related to zoophilic and geophilic species. Keratinophilic fungi and related Dermatophytes in the present study are isolated from playground soils of Ujjain causing Nail

dermatophytosis (*tinea unguium*) is the most common nail infectious disorder and may have several clinical presentations according to the type of fungal invasion of the nail plate. Five major presentations are described: distal and lateral subungual, proximal subungual, white superficial, endonyx, and total dystrophic onychomycosis. The Distal and Lateral Subungual Onychomycosis (DLSO) is usually associated with *tinea pedis* because fungi reach the nail through the hyponychium invading the undersurface of the nail plate and spreading proximally.[20,21] It usually affects one or both great toenails and it is usually caused by *T. rubrum*. Keratinophilic fungi and related Dermatophytes in the present study are isolated from playground soils of Ujjain causing the White Superficial Onychomycosis is usually caused by *T. mentagrophytes*, which invades the dorsal nail plate forming white opaque lesions, easily scraped away. The Proximal Subungual Onychomycosis (PSO) typically occurs in the ventral nail plate, producing a proximal leukonychia and it is rarely related to dermatophytes, being more observed in immunocompromised patients or related to non-dermatophyte infection. Endonyx Onychomycosis is very rare, caused by *T. soudanense* or *T. violaceum*, and is characterized by massive nail plate invasion without nail bed involvement. Total Dystrophic Onychomycosis occurs after long-term DLSO or PSO presenting severe subungual keratosis thickening, and dystrophy of the total nail unit plate[22,23]

Results

Table 1. Keratinophilic fungi and related dermatophytes from playground soils of Ujjain, India (percent area covered in petriplates during isolation)

No.	Name of the Fungi	1	2	3	4	5	%
1	<i>Aspergillus fumigatus</i>	1	2	-	2	3	8
2	<i>A. flavus</i>	2	1	1	-	1	5
3	<i>A. niger</i>	1	1	1	1	-	4
4	<i>A. Terreus</i>	1	2	1	2	1	7
5	<i>Acremonium sp.</i>	1	1	-	1	1	4
6	<i>Alternaria sp.</i>	+	2	-	1	2	5
7	<i>Chrysosporium indicum</i>	1	2	1	2	2	8
8	<i>Chrysosporium tropicum</i>	1	3	1	3	2	10
9	<i>Curvularia lunata</i>	1	1	-	1	1	4
10	<i>Fusarium oxysporium</i>	1	2	1	1	3	8
11	<i>Humicola insolense</i>	1	1	-	1	-	3
12	<i>Microsporum gypseum</i>	1	3	1	3	2	10
13	<i>Malbracehea aurantiaca</i>	1	1	-	-	1	3
14	<i>Penicillium sp.</i>	1	2	1	1	-	5
15	<i>Paecilomyces variotii</i>	1	1	1	-	-	3
16	<i>Trichophyton rubrum</i>	-	1	1	1	1	4
17	<i>T. mentagrophyte</i>	1	2	1	1	1	6
18	<i>Scytalidium sp.</i>	1	2	-	-	2	5
	Total	17	30	11	21	23	102

Diagnosis of dermatophytoses involves the direct microscopic analyses of the skin and nail scales, where any dermatophyte presents as septate, branched hyaline hyphae that can disarticulate, resulting in arthroconidia. In hair, dermatophytes also appear as hyphae or arthroconidia chains being classified in three types of parasitism: (1) *ectothrix*, when hyphae and arthroconidia are distributed around and inside the tonsured hair shaft (2) *endothrix*, when hyphae and arthroconidia are distributed inside the tonsured hair shaft; and (3) *favic*, when hyphae and arthroconidia are distributed inside the hair shaft, without tonsure. Dermatophytes grow well in Sabouraud and Mycosel Agar after incubation at 25°C

for 10 days on average. All dermatophytes are resistant to cycloheximide present in Mycosel Agar, which helps in their isolation in this media. The species are routinely identified by macroscopic (texture and pigment of the colonies) and microscopic (morphology and abundance of macroconidia and microconidia) analyses of fungi isolated in these media.[24] Identification can also be provided by Matrix-assisted laser desorption/ionization time of flight mass spectrometry (MALDI-TOF).

Treatment of dermatophytoses usually requires topical antifungals although oral drugs (itraconazole, terbinafine) should be prescribed in case of extensive lesions, failed topical treatment, immunocompromised host, *tinea capitis*, and frequently for *tinea unguium*. The time of treatment depends on the site of infection. Palm-plantar, hair and nail infections require longer time treatment. For prevention purposes, do not share objects of personal use, wear shoes in public collective environments, wash and dry feet and intertriginous areas well, avoid close contact with animals, fomites, and environmental sources as soil. In case of zoophilic transmission, it is important to take the domestic animal to veterinary evaluation and treatment, when indicated. When the agent involved is anthropophilic, it is recommended to examine all domiciliary contacts. Once treatment is started, the patient can return to his/her labor activities.

Hyphopichia burtonii has been reported as a cause of fungal dermatitis in a free-ranging *Barbastella barbastellus*. In this case report, gross lesions included skin thickening, crusting, ulceration, and nodule formation. Thin, branching, septate fungal hyphae and masses of ~4 µm diameter ovoid spores were within the stratum corneum and hair follicles with epidermal hyperplasia and follicular hyperkeratosis. Fungal dermatitis has also been associated with *Cladosporium* spp. in a euthermic *Vespertilio murinus* with white foci on wing membranes and severe necrotizing dermatitis with intralesional fungal hyphae.[25]

Bats can serve as reservoirs for *Histoplasma capsulatum*, although clinical disease in free-ranging bats is uncommon. Organisms are most often present in pulmonary alveolar macrophages but can also be found in circulating macrophages and in the mesentery, spleen, liver, adrenal gland, and intestine. There is typically minimal to no cellular response to infection, which is thought to occur by the respiratory route with infective fungi being excreted in faeces. There are no reports of mortality due to natural infections in free-ranging bats. The ability of bats to survive disseminated infection, including intestinal infection with shedding of spores, likely allows them to serve as reservoirs. Keratinophilic fungi and related Dermatophytes in the present study are isolated from playground soils of Ujjain ie. *Rousettus aegyptiacus* and one *Artibeus jamaicensis* had systemic histoplasmosis. The lung was a primary site of infection in all cases except 4 *R. aegyptiacus*.[26]

Conclusions

Keratinophilic fungi and related Dermatophytes in the present study are isolated from playground soils of Ujjain are transferred to Juvenile pteropodid bats with poor husbandry or chronic illness can develop cutaneous *Candida albicans* infections, most commonly on the wing membranes. Lesions initially present as erythema progressing to a gray, slimy pseudomembrane from which hair epilates in clumps. Concurrent cutaneous and oral candidiasis is sometimes identified. Oral candidiasis is common in hand-raised pteropodid bats, and gastric candidiasis may occur in pteropodid bats consuming inappropriately nutrient-dense diets, as well as in immunosuppressed or debilitated pups, especially after prolonged antibiotic administration. Oral and oesophageal candidiasis is sometimes observed in captive bats, with neutrophilic infiltrates, erosions, ulcers, or necrosis of the mucosa and intralesional 2–6 µm diameter ovoid budding yeasts and 3–5 µm diameter hyphae and pseudohyphae. Keratinophilic fungi and related Dermatophytes in the present study are isolated from playground soils of Ujjain transferred to often these animals have received antibiotics or have other concurrent disease

processes. Occasional captive pteropodid bats have keratitis and/or conjunctivitis associated with *Candida*.^[26]

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