Dermatophytes, dermatophytosis in the Caribbean and potential for herbal therapy

Harish C. Gugnani

Departments of Microbiology and Epidemiology and Biostatistics, Saint James School of Medicine, Anguilla, British West Indies; Professor of Medical Mycology (Retired), VP Chest Institute, University of Delhi, India

Abstract

Introduction: Dermatophytes are a group of morphologically related keratinophilic fungi that invade keratinized tissue (skin, hair, and nails) of humans and warm-blooded animals to produce clinical lesions (dermatophytosis). Clinical lesions are traditionally divided according to the site infected, namely, scalp (tinea capitis), feet (tinea pedis, commonly called “athletes’ foot”), groin, inner thighs, or buttocks (tinea cruris, commonly called “jock itch”), beard (tinea barbae), hands (tinea manuum), toe nails or finger nails (tinea unguium, also called onychomycosis), face, non-bearded area (tinea faciei) and other parts of the body, such as arms, abdomen, or legs (tinea corporis). Dermatophytosis is common world-wide and is caused by species of three genera of dermatophytes, namely Microsporum, Trichophyton, and Epidermophyton. This study presents an update of ecology of different species of dermatophytes and epidemiology of infections caused by them in the Caribbean. Possibility of herbal therapy of these infections as an alternative treatment is also dealt with.

Methods: A thorough search of literature was made using PubMed, MEDLINE, Biomed Lib, Med Facts, and different sets of key words, viz. dermatophytes, tineas in Caribbean, occurrence in animals, soil etc.

Results: It was revealed that incidence of dermatophytic infections and their epidemiologic characteristics depend on social, geographic, and environmental factors and may change with passage of time. For instance, prior to year 2000, the major cause of tinea capitis in North America for 100 years was Microsporum canis followed by M. audouinii; Since 1950 Trichophyton tonsurans has advanced from Mexico and the Caribbean to be currently a major cause of tinea capitis in North America. The two dermatophytes Microsporum gypseum and M. fulvum, and several Chrysosporium species have been frequently isolated form soils in different countries in the Caribbean.

Conclusions: There is almost complete lack of information on human infections due to dermatophytes in several Caribbean countries. The preponderant occurrence of M. fulvum in Anguilla soils with comparatively rare isolation of M. gypseum is a significant observation. The need for further epidemiological studies on dermatophylosis in the Caribbean countries cannot be overemphasized.

Introduction

Dermatophytes are a group of morphologically related filamentous fungi that have the capacity to invade keratinized tissue (skin, hair, and nails) of humans and warm-blooded animals to produce clinical lesions (dermatophytosis), commonly referred to as “ringworm” because of the ring-shaped lesions. Dermatophytes cause a variety of clinical conditions collectively termed as dermatophytosis. The dermatophytes include about thirty clinically relevant species, but their taxonomy has been controversial because of incongruence of phenotypic and molecular characters. In this paper we would follow the traditional classification.

Dermatophytosis is common world-wide and is caused by species of three genera of dermatophytes, namely Microsporum, Trichophyton, and Epidermophyton. Infections caused by these organisms are referred to as tineas which precedes the Latin name for the site which they involve. From an ecological and epidemiological point of view, the dermatophytes are classified in to three groups based on their mode of transmissions; geophilic (found in soil and infect both animals and humans), zoophilic (found on animals, but can be transmitted to humans), and anthropophilic (found on humans, but may can occasionally infect animals). Zoophilic and anthropophilic dermatophytes evolved from a geophilic origin, with the anthropophilic dermatophytes being the most highly specialized group. Geophilic and zoophilic dermatophytes generally tend to form lesions that are more inflammatory than those produced by anthropophilic dermatophytes, and those lesions are also more likely to heal spontaneously. The incidence of dermatophytic infections and their epidemiologic characteristics depend on social, geographic, and environmental factors and may change with passage of time.

M. audouinii and M. canis, once major agents of...
Tinea capitis in the United States, have been overtaken by Trichophyton tonsurans. Since the 1950s, T. tonsurans has advanced from Mexico and the Caribbean and is now the major etiological agent of tinea capitis in North America. Microsporum canis is the principal agent of tinea capitis in many regions of the world; this could be related to close association of humans with their pets. Also, M. canis is more prevalent in urban areas and T. mentagrophytes in rural areas. The clinical manifestations of infection vary depending on the infecting fungus, the body site infected, and the immune status of the host. The dermatophytosis are traditionally divided according to the site infected, namely, scalp (tinea capitis), feet (tinea pedis, commonly called “athletes’ foot”), groin, inner thighs, or buttocks (tinea cruris, commonly called “jock itch”), beard (tinea barbae), hands (tinea manuum), toe nails or finger nails (tinea unguium, also called onychomycosis), face, non-bearded area (tinea faciei) and other parts of the body, such as arms, abdomen, or legs (tinea corporis). Several anatomic sites may be infected by a single species of dermatophytes, and different species may produce clinically identical lesions. 6

Methods
All published papers on dermatophytes in various Caribbean countries were scanned by extensive and thorough search of literature using PubMed, MEDLINE, Biomed Lib, Med Facts, and different sets of key words, viz. dermatophytes, tineas in Caribbean, occurrence in animals, soil etc. The recent unpublished work on occurrence of dermatophytes in Anguilla soils is also included.

Table 1. Prevalence of Dermatophyte species in the Caribbean.

| Country       | Clinical entity | No. of cases | No. (%) of isolates of different species                                                                 | Reference no. |
|---------------|-----------------|--------------|----------------------------------------------------------------------------------------------------------|---------------|
| Cuba          | Tinea capitis   | 240          | Microsporum canis 182 (73.1%), Trichophyton tonsurans 56 (22.5%), T. mentagrophytes 3 (1.2%), M. gypseum 5 (2.0%), mixed due to M. canis and T. tonsurans 3 (1.2%) | 7             |
| Cuba          | Tinea cruris    | 227          | T. rubrum 219 (96.5%), T. mentagrophytes 3 (1.3%), T. tonsurans 2 (0.9%), M. gypseum 2 (0.9%) and E. floccosum 1 (0.4%) | 7             |
| Cuba          | Tinea corporis  | 78           | M. canis 46 (59.0%), T. mentagrophytes 15 (19.2%), M. gypseum 7 (9.0%), T. tonsurans 3 (3.8%), and E. floccosum 1 (1.3%) | 7             |
| Cuba          | Onychomycosis   | 144          | T. rubrum 137 (95.1%)                                                                                                | 7             |
| French Guiana | Tinea capitis   | 119          | T. tonsurans 88 (73.9%), T. mentagrophytes 10 (8.4%), M. canis 9 (7.5%), M. audouinii 6 (5.0%), M. gypseum 2 (1.7%), M. langeronii 1 (0.8%), T. rubrum 1 (0.8%) and M. langeronii 1 (0.8%) | 8             |
| French Guiana | Tinea pedis     | 52           | T. rubrum 36 (70.6%), T. mentagrophytes 11 (21.5%), E. floccosum 2 (3.9%), M. canis 1 (1.9%) and T. shoemakeri 1 (1.9%) | 8             |
| French Guiana | Tinea corporis  | 42           | T. rubrum 22 (52.4%), M. canis 7 (16.6%), E. floccosum 3 (7.1%) & T. mentagrophytes 3 (7.1%), M. audouinii 1 (2.4%) and M. pncecox 1 (2.4%) | 8             |
| Dominican Republic | Tinea capitis | 118         | T. tonsurans 61 (53.6%), M. audouinii 24 (22.7%), M. canis 11 (9.6%), T. violaceum and T. mentagrophytes rarely isolated | 9             |
| Haiti         | Tinea capitis   | 55           | T. tonsurans 35 (63.69%), T. mentagrophytes 8 (14.5%), T. rubrum 4 (7.3%), M. audouinii 7 (12.7%) and M. gypseum 1 (1.8%) | 10            |
| Trinidad      | Tinea capitis   | No. of cases not mentioned | T. tonsurans 52 (9.9%), M. canis 20 (4%), M. audouinii 18 (6.8%), M. gypseum 1.9%, T. mentagrophytes 1.4% and T. rubrum 1.4% | 11            |
| Jamaica       | Tinea capitis   | 82           | T. tonsurans 36 (43.9%), M. audouinii 31 (37.8%), T. mentagrophytes 7 (8.5%), Trichophyton sp 2 (2.4%), M. canis 1 (1.2%) and M. gypseum 1 (1.2%) | 12            |
| Barbados      | Tinea capitis   | N            | T. mentagrophytes and E. floccosum, data on frequency of these species not available                          | 13            |
| Puerto Rico   | Tinea capitis   | 38           | M. canis 14 (38.9%), T. mentagrophytes 7 (19.4%), T. rubrum 7 (19.4%) and M. gypseum 5 (13.9%) | 14            |
| Puerto Rico   | Tinea corporis and Tinea pedis | 48 | T. rubrum 42 (85.7%), E. floccosum 4 (8.1%), T. mentagrophytes 2 (4%) and M. fenumegineum 1 (2%) | 15            |
| Puerto Rico   | All tineas due to dermatophytes=803 No. of cases not mentioned | T. mentagrophytes 350 (43.6%), T. rubrum 304 (37.9%), T. tonsurans 70 (8.7%), M. canis 42 (5.2%), E. floccosum 26 (3.2%), M. gypseum 9 (1.1%), M. audouinii 2 (0.2%) | 16            |
Guiana was a 22 years-old woman with tumefaction of the scalp evolving over five years, while the one from Dominican Republic was of eight years duration in a woman, the swelling evolving from purulent nodular lesions that occurred on the scalp 14 years ago.

There is almost complete lack of information on the occurrence of dermatophytic infections in the Dutch Caribbean. Poborst et al. listed one isolate of T. mentagrophytes (CBS 102.680) (earlier identified as T. interdigitale) recovered from pus of lesion in a man. This indicates that human infections due to T. mentagrophytes and other species of dermatophytes occur in the Dutch Caribbean but have not been studied or recognized.

A thorough search of literature did not reveal any publication of dermatophytosis (ringworm) in animals in the Caribbean. However, it may be mentioned here that two fungal isolates from ringworm lesions in dogs from the veterinary clinic in Ross University School of Veterinary Medicine, St. Kitts and Nevis, were identified as M. gypseum by the senior author of this paper.

Regarding natural occurrence of dermatophytes, out of 163 soil samples examined from St. Kitts and Nevis, 39 (23.9%) were positive for M. gypseum complex. In Bonaire, out of 76 soil samples examined 16 (21.0%) were positive M. gypseum (Perfect Stage, Nannizia incurvata), and 8 (10.5%) were positive for M. fulvum (PS Nannizia fulva). Of the 46 soil samples examined from Jamaica, 16 (34.8%) yielded M. gypseum, and 4 (8.7%) were positive for M. fulvum. Investigation of 110 soil samples from Anguilla yielded M. fulvum from 35 samples, and M. gypseum from 8 samples. M. gypseum is the only dermatophyte recovered from soil in Barbados.

**Discussion**

As is evident from the results of our literature search (Table 1), Trichophyton tonsurans is currently the major agent of tinea capitis in Haiti, Dominican Republic and French Guiana, while in Cuba it is M. canis. The prevalence of T. rubrum as the commonest agent of tinea corporis, tinea pedis and onychomycosis in French Guiana agrees with that reported from Europe, whereas the frequency of T. tonsurans in tinea capitis agrees with that in the Americas. There has been a gradual shift in the dominant agent of tinea capitis in Jamaica, it was M. audouini in 1998 then replaced by T. tonsurans. The report of an autochthonous case of tinea capitis due to M. ferrugineum in Puerto Rico is noteworthy.

Preponderant occurrence of M. fulvum in Anguilla soils with rare isolation of M. gypseum is a significant observation. Very recently, a new species of dermatophyte, Nannizia polymorpha was isolated from a skin lesion of a patient from French Guiana. There is need for further epidemiological studies on dermatophyosis and natural occurrence of dermatophytes in the environmental sources in the Caribbean.

Dermatophytes due to dermatophytoses is occasionally encountered, mainly observed on the scalp and nape of the neck, frequently with a history of a skin lesion leading to transcutaneous penetration of the fungus and dermatoma formation. Though several dermatophytes have been identified as etiological agents, mycetoma due to M. canis is rare with reports of only two cases in children, one each from Africa and Australia. It is noteworthy that two cases of mycetoma, one each from French Guiana and from Dominican Republic were traced in our literature search.

Majority of clinically used antifungal compounds have several drawbacks in terms of toxicity, efficacy and cost, and their frequent use has led to the emergence of resistant strains. The spread of multidrug-resistant strains of pathogenic fungi including dermatophytes has motivated several investigators to discover new classes of antifungal compounds that inhibit these resistant mechanisms. Natural products from plants have played a central role in exploring novel drugs, making it noteworthy objective in drug industry as well in health care. There is also public concern to restrict the use of synthetic antimicrobial drugs because of their impact on agriculture and environment. This has also led to a search for medicinal plants and compounds isolated from them for their antifungal properties. Abed et al. reviewed the numerous publications relating to compounds derived from plants with antimycotic activity.

Verastegui et al. investigated the antifungal activity of several plants in the vegetation of Mexico and southern USA for a variety of pathogenic fungi including dermatophytes. Okunji et al. demonstrated strong antifungal activity of a spirostal saponin (DM-1), isolated from the fruit pulp of Dracaena manii (small-leaved dragon) a shrub common in West Africa, against 17 species of fungi including dermatophytes. The structure of DM-1 was characterized as 3β-[α-L-rhamnopyranosyl (1→2)-α-L-rhamnopyranosyl (1→3)]-β-D-glucopyranosyl]-17 ω-hydroxy-spirost-5-en-ene from the analysis of the spectra data and chemical reactions. Vaijayanthimala et al. tested the antifungal activity of 23 south Indian medicinal plants against clinical isolates of Trichophyton rubrum and T. mentagrophytes; alcoholic extracts of Allium sativum (Garlic), and A. schoenoprasum (chives) showed highest anti-dermatophytic activity. In another publication from south India, Balakumar et al. demonstrated significant in vitro antifungal activity of Ocimum sanctum (Tulsi) against clinical isolates of T. rubrum, T. mentagrophytes, Epidermophyton floccosum and Microsporum gypseum. Ocimum sanctum being common in the Caribbean and grown in many home gardens holds particularly good promise for herbal therapy of dermatophytic infections in this region.

The Caribbean is regarded as one of the world’s centers of biodiversity. Information on screening of Caribbean plants on antimicrobial properties has been lacking. A study from Puerto Rico by Luciano-Montalvo et al. screened thirteen plants locally known to have medicinal properties for antimicrobial activity against isolates of five pathogenic bacteria, namely Staphylococcus aureus, S. saprophyticus, Escherichia coli, Hemophilus influenzae, Proteus vulgaris, one of Candida albicans, a well-known pathogenic fungus. This study confirmed the traditional use of Pityrogramma calomelanos for the treatment of kidney infections associated with stones, and the bactericidal effects of Tapeinoschis ananassae against P. vulgaris and S. saprophyticus and that of Syzygium jambos against S. aureus and S. saprophyticus; however, there was no activity against C. albicans.

There are many Caribbean medical schools with competent faculty staff in their departments of microbiology and biochemistry. It would be a laudable effort for them to investigate with possible international collaboration the antibacterial and antifungal properties of the local herbs, including the plant Ocimum sanctum (Tulsi) known to have significant anti-dermatophytic activity. Hopefully this would lead to development of cost-effective, herbal therapy for fungal infections in the Caribbean region.

**References**

1. Hayette MP, Acheli R. Dermatophytes, trends in epidemiology and diagnostic approach. Curr Fungal Infect Rep 2015;9:164-79.
2. Graser Y, el Fari M, Presber W, et al. Identification of common dermatophytes (Trichophyton, Microsporum, Epidermophyton) using polymerase chain reactions. Br J Dermatol 1998;138: 576-82.
3. Ajello L. Geographic distribution and prevalence of the dermatophytes. Ann N Y Acad Sci 1960; 89: 30-8.
4. Ajello L. Natural history of dermatophytes and related fungi. Mycopathol Mycol Appl 1974; 53: 93-110.
5. Padhye AA, Summerbell RC. Dermatophytes. In: Merz WG, and Hay J, eds. Topley & Wilsons Microbiology and Microbial Infections: Medical Mycology, Vol. 6, London: Arnold 2010. p. 220-230.
6. Havlickova B, Czaika VA, Friedrich M. Epidemiological trends in skin mycoses worldwide. Mycoses 2008; 5: 2-15.
7. Paedo-Castello V, Trespalacllos F. Superficial and deep mycoses in Cuba. South Med J 1959; 52: 7-15.
8. Simonet CC, Berger F, Ganther J-C. Epidemiology of superficial fungal diseases in French Guiana: A three-year retrospective analysis. Med Mycol 2011; 49: 608-11.
9. Arenas R, Torres E, Amaya M, et al. Emergence of Microsporum audouinii and Trichophyton tonsurans as causative organisms of tinea capitis in the Dominican Republic. Actas Dermosifiliogr 2010; 101: 330-5.
10. Raccurt CP, Dorsainvil D, Boncy M, et al. The emergence of Trichophyton tonsurans in Port-au-Prince, Haiti. Med Mycol 2009; 47: 197-200.
11. Moore MK, Suite M. Tinea capitis in Trinidad. J Trop Med Hyg 1993; 96: 346-8.
12. East-Innis A, Rainford L, Dunwell P, et al. The changing pattern of tinea capitis in Jamaica. West Indian Med J 2006; 55: 85-8.
13. McCaskie S. Dermatophytes in Barbados, M. Phil Thesis, University of The West Indies (Cave Hill, Barbados), 1982. Available from: http://hdl.handle.net/2139/3374.
14. Ross S, Rubianes EL, Lugo-Somolinos A, et al. Epidemiological study of tinea capitis in Jamaica. West Indian Med J 2006; 55: 85-8.
15. Vázquez M, Sánchez JL. A clinical and mycologic study of tinea corporis and pedis in Puerto Rico. Puerto Rico Health Sci J 1993; 12: 287-9.
16. Carion A. Dermatomycoses in Puerto Rico. Clinical Studies. Archives of Dermatology 1965; 91: 431-438.
17. Ajello L, Varsavsky E, Ginther OJ, Bubash G. The natural history of Microsporum nanum. Mycologia 1964; 56: 873-84. doi:10.1080/00275514.12018178
18. Vezon G, Desbois N, Boisseau-Garsaud AM. Microsporum canis mycetoma of the scalp [French]. Ann Dermatol Venereol 2000; 127: 729-31.
19. Isa R, de Estevez FN, Arena R. Mycetoma caused by dermatophytes: A case due to Microsporum canis. J Mycol Med 2003; 13: 151-3.
20. Probst S, de Hoog GS, Graser Y. Development of DNA markers to explore host shifts in dermatophytes. Stud Mycol 2002; 45: 57-74.
21. Gugnani HC, Soni S, Gupta B, Gaddam S. Prevalence of keratinophilic fungi in soils of St. Kitts and Nevis. J Infect Dev Ctries 2012; 6: 347-50.
22. Gugnani HC, Dortalina R, Rosalia J, et al. Kakava. Prevalence of keratinophilic fungi in soils of Bonaire (Dutch Carribean). Trans Indian Mycol Soc 2013; 41: 1-5.
23. Gugnani HC, Soni S, Wright K. A preliminary study of keratinophilic fungi of soils of Jamaica. Revista do Instituto de Medicina Tropical de São Paulo 2014; 56: 231-4.
24. Gugnani HC, Venkatesan K. Dermatophytes and other keratinophilic fungi in the soils of Anguilla, British West Indies (BWI). Microbiol Res Int J 2020; 30: 1-6.
25. Dukik A, de Hoog GS, Stielow JB, et al. Molecular and phenotypic characterization of Nannizzia Arthrodermataceae. Mycopathologia 2020; 185: 9-35. doi: 10.1007/s11046-019-00336-9.
26. Abad MJ, Ansuategui M, Bermejo P. Active antifungal substances from natural sources. ARKVOC 2007; 7: 116-45.
27. Verastegui, MA, Sanchez CA, Heredia NL, Garcia-Alvarado JS. Efficacy and phytochemical analysis of latex of Calotropis procera against selected dermatophytes. J Ethnopharmacol 1996; 52: 175-7.
28. Okunji CO, Okeke CN, Gugnani HC, Iwu MM. An antifungal spirostanol saponin from fruit pulp of Dracaena mannii. Int J Crude Drug Res 1990; 28: 193-9. doi: 10.3109/1388029090090 82811
29. Vaijayanthimala J, Prasad NR, Anandi C, Pugalendi KV. Antidermatophytic activity of some Indian medicinal plants. J Ethnopharmacol 2004; 4: 26-31.
30. Balakumar S, Rajan S, Thirunalasundari T, Jeeya S. Antifungal activity of Ocimum sanctum Linn. (Lamiaceae) on clinically isolated dermatophytic fungi. Asia-Pacific J Trop Med 2011; 4: 56-57.
31. Eshbaugh, WH. Medicinal Plants of the West Indies. Econ Bot 1984; 38: 133. doi: 10.1007/BF02904426
32. Luciano-Montalvo C, Boulogue I, Gavillan-Suárez J. A screening for antimicrobial activities of Caribbean herbal remedies. BMC Complement Altern Med 2013; 13: 126-34. http://www.biomedcentral.com/1472-6882/13/126