Original Article

Epidemiology of Dermatophytoses in Crete, Greece: a 5-year Survey

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ABSTRACT

Dermatophytoses are among the most frequently diagnosed skin infections worldwide. However, the distribution of pathogenic species and the predominating anatomical sites of infection vary with geographical location and change over time. The aim of this study was to determine the epidemiological and aetiological factors of dermatophytoses in Crete, Greece over the last 5-year period (2011-2015) and their incidence in relation to the gender and the age of the patients. We compared our findings with those previously reported from the same area and from other parts of the world. A total of 2,910 clinical specimens (skin scrapings, nail clippings, and hair specimens) obtained from 2,751 patients with signs of dermatomycoses were examined using direct microscopy and culture. Overall, 294 specimens (10.1%) were proved mycologically positive for dermatophytes. The age of the patients ranged from 2 to 86 years (mean age, 37 years). Tinea corporis was the predominant clinical type of infection, followed by tinea unguium, tinea pedis, tinea capitis, tinea faciei, tinea cruris and tinea manuum. Among dermatophytes, eight species were isolated: Microsporum canis (35.8%), Trichophyton rubrum (35.1%), Trichophyton mentagrophytes (23.3%), Epidermophyton floccosum (2.5%), Microsporum gypseum (1.8%), Trichophyton violaceum (0.7%), Trichophyton verrucosum (0.4%), and Trichophyton tonsurans (0.4%). In our area, the most common dermatophyte was M. canis followed by T. rubrum. Increased migration, mass tourism, and climate changes will contribute to further changes in the epidemiology of dermatophytoses in our area. Continuing studies are necessary for determining the new epidemiological trends and to implement the appropriate control measures.

Key words: dermatophytosis, epidemiology, Greece, ringworm, tinea

Introduction

Dermatophytoses are fungal infections of the skin, hair, and nails caused by filamentous keratinophilic fungi belonging to three genera: Trichophyton, Microsporum, and Epidermophyton¹. They are among the most frequently encountered causative agents of superficial mycoses, leading to tinea infections that are classified according to the affected body site². The distribution of dermatophytes varies with geographical location and change by time, being influenced by several factors, such as climatic variations, migration, socioeconomic conditions, lifestyle, age, underlying diseases, and immunocompetence of the host³⁻⁵. Consideration of the current epidemiology is important for treatment and effective control of the infection⁶.

Many studies have investigated the prevalence of dermatophytoses in different regions of the world and in many parts of Greece⁷⁻¹⁰. Crete is the biggest island located in the southernmost part of the country. The island is visited by thousands of tourists all year around, and currently many immigrants arrive every day. Consequently, the distribution of some species will be influenced, and the epidemiological profile will be changed in this geographical area.

The purpose of this study was to determine the
causative agents of dermatophytoses by age, gender, and affected body site in patients admitted to the University Hospital of Heraklion, in Crete, Greece between 2011 and 2015. The results were compared with those previously reported from the same area, Greece, Europe, and other regions of the world.

Material and methods

During a 5-year period (2011-2015), a total of 2,910 specimens obtained from patients with clinically suspected dermatomycosis were examined in the Mycology Laboratory at the University Hospital of Heraklion, Crete, Greece. Gender, age, site of involvement, and contact with animals were recorded for each patient.

The pathological material (hair, skin scales, nail fragments) was subjected to direct microscopy and culture. Microscopy of specimens was carried out after the addition of 2-3 drops of 20% KOH solution with 36% dimethylsulfoxide. Cultures were performed on Sabouraud dextrose agar containing chloramphenicol, and on Sabouraud dextrose agar containing chloramphenicol and cycloheximide (bioMérieux, S.A., Marcy l’Etoile, France). Plates were incubated at 25-28°C for 21 days and were examined twice weekly. Incubation of plates showing no growth in 21 days was prolonged for one additional week before discarding them. Identification of the isolated dermatophytes was carried out on the basis of the macroscopic and microscopic characteristics of the fungi, urea testing, growth on Trichophyton agars, and hair perforation assays.

Statistical analysis of data was based on chi-square test. A difference between groups was considered significant when $P < 0.05$.

Results

Out of 2,910 clinical specimens obtained from 2,751 patients with signs of dermatomycoses, 294 (10.1%) were proved mycologically positive for dermatophytes by direct microscopic examination and/or culture. Of these, 15 (5.1%) were found to be positive by direct microscopy only, 6 (2%) were found to be positive by culture only, while 273 were found to be positive by both techniques — direct examination and culture. One hundred and fifty-five (52.7%) of the 294 patients were males and 139 (47.3%) were females. The age range was 2-86 years (mean, 37 years).

The dermatophytic species isolated and their frequencies are shown in Table 1. M. canis was the most frequently isolated species, followed by T. rubrum, T. mentagrophytes, and E. floccosum. These dermatophytes represented 96.7% of the strains isolated.

Tinea corporis (34.4%) was the most common type of infection, followed by tinea unguium (20.1%), tinea pedis (17.2%), tinea capitis (12.6%), tinea faciei (8.6%), tinea cruris (3.9%), and tinea manuum (3.2%) (Table 2). The prevalence of the various dermatophytes varied between different sites of infection (Table 2). M. canis was the most common cause of ringworms of the body, scalp, and face, while T. rubrum was the most prevalent dermatophyte isolated from tinea unguium, tinea pedis, and tinea cruris. The distribution of dermatophyte infections in male and female patients is shown in Table 2.

Tinea capitis was more frequently observed in children and teenagers. Tinea corporis was observed among patients of all age groups, but had maximum prevalence among children < 15 years. Tinea unguium occurred mostly among patients 46-60 years old (Table 3).

Table 4 indicates the frequency with which the different species occurred in relation to the age of the patients. M. canis was isolated most frequently from patients aged < 15 years, while T. rubrum and T. mentagrophytes were more frequently found in dermatomycoses of patients 31-45 years. Dermatophytoses occurred throughout the year with substantially higher incidence of M. canis and T. mentagrophytes infections in fall, and T. rubrum infections in summer and winter (Fig. 1).

**Table 1. Aetiological agents of dermatophytoses in Crete, Greece (2011-2015)**

<table>
<thead>
<tr>
<th>Species</th>
<th>No.</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microsporum canis</td>
<td>100</td>
<td>35.8</td>
</tr>
<tr>
<td>Trichophyton rubrum</td>
<td>98</td>
<td>35.1</td>
</tr>
<tr>
<td>Trichophyton mentagrophytes</td>
<td>65</td>
<td>23.3</td>
</tr>
<tr>
<td>Epidermophyton floccosum</td>
<td>7</td>
<td>2.5</td>
</tr>
<tr>
<td>Microsporum gypseum</td>
<td>5</td>
<td>1.8</td>
</tr>
<tr>
<td>Trichophyton violaceum</td>
<td>2</td>
<td>0.7</td>
</tr>
<tr>
<td>Trichophyton verrucosum</td>
<td>1</td>
<td>0.4</td>
</tr>
<tr>
<td>Trichophyton tonsurans</td>
<td>1</td>
<td>0.4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>279</td>
<td>100</td>
</tr>
</tbody>
</table>
Dematophytoses are among the most frequently encountered superficial mycoses worldwide. It has been estimated that they account for 5% of all skin disorders in Greece.

Dermatophytic infections vary in terms of causative agents and their prevalence according to geographical location and over time in the same area, mainly due to climatic and socioeconomic conditions. In Europe, the incidence and distribution of dermatophytes have changed significantly over the last few decades.


Previous studies from the same area showed that the decrease was gradual. Studies from other parts of Greece have demonstrated a similar decline that reflects improved social conditions and sanitary standards.

M. canis was the most prevalent dermatophyte species isolated from 35.8% of dermatophytic infections.

### Table 2. Distribution of the various dermatophyte species in relation to gender and the site of infection

<table>
<thead>
<tr>
<th>Dermatophyte</th>
<th>Tinea corporis</th>
<th>Tinea unguium</th>
<th>Tinea pedis</th>
<th>Tinea capitis</th>
<th>Tinea faciei</th>
<th>Tinea cruris</th>
<th>Tinea manuum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microsporum canis</td>
<td>17/33</td>
<td>0/2</td>
<td>0/1</td>
<td>19/14</td>
<td>8/5</td>
<td>0/1</td>
<td></td>
</tr>
<tr>
<td>Trichophyton rubrum</td>
<td>14/5</td>
<td>22/17</td>
<td>15/11</td>
<td>2/3</td>
<td>4/2</td>
<td>2/1</td>
<td></td>
</tr>
<tr>
<td>Trichophyton mentagrophytes</td>
<td>12/10</td>
<td>7/6</td>
<td>8/9</td>
<td>1/1</td>
<td>3/2</td>
<td>1/2</td>
<td></td>
</tr>
<tr>
<td>Epidermophyton floccosum</td>
<td>1/0</td>
<td>0/1</td>
<td>2/2</td>
<td>1/0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microsporum gypseum</td>
<td>0/3</td>
<td>0/1</td>
<td>1/0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trichophyton violaceum</td>
<td>1/0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trichophyton verrucosum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trichophyton tonsurans</td>
<td>1/0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>45/51</td>
<td>30/26</td>
<td>25/23</td>
<td>20/15</td>
<td>13/11</td>
<td>6/5</td>
<td>6/3</td>
</tr>
</tbody>
</table>

M: male; F: female.

### Table 3. Age distribution of patients with dermatophytosis according to the type of tinea

<table>
<thead>
<tr>
<th>Tinea</th>
<th>Age group (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; 15 y</td>
</tr>
<tr>
<td>Tinea corporis</td>
<td>26.1</td>
</tr>
<tr>
<td>Tinea unguium</td>
<td>0</td>
</tr>
<tr>
<td>Tinea pedis</td>
<td>0</td>
</tr>
<tr>
<td>Tinea capitis</td>
<td>94.2</td>
</tr>
<tr>
<td>Tinea faciei</td>
<td>45.8</td>
</tr>
<tr>
<td>Tinea cruris</td>
<td>9.1</td>
</tr>
<tr>
<td>Tinea manuum</td>
<td>22.2</td>
</tr>
</tbody>
</table>

All values are in percentages.

### Table 4. Age distribution of patients with dermatophytoses according to the dermatophyte species

<table>
<thead>
<tr>
<th>Dermatophyte</th>
<th>Age group (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; 15 y</td>
</tr>
<tr>
<td>Microsporum canis</td>
<td>61</td>
</tr>
<tr>
<td>Trichophyton rubrum</td>
<td>2</td>
</tr>
<tr>
<td>Trichophyton mentagrophytes</td>
<td>13.8</td>
</tr>
<tr>
<td>Epidermophyton floccosum</td>
<td>0</td>
</tr>
<tr>
<td>Microsporum gypseum</td>
<td>0</td>
</tr>
<tr>
<td>Trichophyton violaceum</td>
<td>0</td>
</tr>
<tr>
<td>Trichophyton verrucosum</td>
<td>0</td>
</tr>
<tr>
<td>Trichophyton tonsurans</td>
<td>0</td>
</tr>
</tbody>
</table>

All values are in percentages.

**Discussion**

Dermatophytoses are among the most frequently encountered superficial mycoses worldwide. It has been estimated that they account for 5% of all skin disorders in Greece. Dermatophytic infections vary in terms of causative agents and their prevalence according to geographical location and over time in the same area, mainly due to climatic and socioeconomic conditions. In Europe, the incidence and distribution of dermatophytes have changed significantly over the last few decades.

The present survey revealed a significant decrease in the incidence of dermatophytoses in Crete from 24.2% (1992-1996) to 10.1% (2011-2015). Previous studies from the same area showed that the decrease was gradual. Studies from other parts of Greece have demonstrated a similar decline that reflects improved social conditions and sanitary standards.

Microsporum canis was the most prevalent dermatophyte species isolated from 35.8% of dermatophytic infec-
tions, followed by *T. rubrum* (35.1%). Previous epidemiological studies from Crete have shown that *T. rubrum* was the most common species from 1992 to 2010. The present study revealed that the incidence of *M. canis* significantly increased, compared with previous assessments (*P < 0.0001*). A recent epidemiological survey from southwestern Greece has shown that *M. canis* is the most common species present since 1991. Mostly cats and dogs serve as the reservoir of the dermatophyte. Investigators in central Italy found that cats living in rural areas are more frequently infected by *M. canis*. All 100 stray cats examined were found infected by the dermatophyte, while 8% of cats living in private households were asymptomatic carriers of *M. canis*. Similarly, Khosravi et al. found that 84.6% of the stray cats harbouring *M. canis* were asymptomatic. The low incidence of *M. canis* in the Grenoble area of France is explained by the absence of wandering cats in the city. On the contrary, in Crete, stray cats and dogs are increasing, despite sporadically implemented measures. *M. canis* was the only dermatophyte isolated from 40% of cats and dogs in northern Italy. A similar epidemiologic situation was also reported from southern Italy. The infectious arthrospores from the fur of the cats survive in the environment and retain its virulence for a year. Humans can become infected by direct contact with sick animals, healthy carriers, or by contact with contaminated dust, brushes, or clothing.

*Tinea corporis* was the main clinical type encountered, and it accounted for 34.4% of all infections. This finding is in agreement with our previous data from Crete and from southwestern Greece. Similarly, in central and northern Italy, central Poland, and Slovenia, tinea corporis is the most commonly diagnosed clinical type.

*M. canis* was the most frequent aetiological agent (52.1%), followed by *T. mentagrophytes* (22.9%) and *T. rubrum* (19.8%). According to several epidemiologic studies worldwide, the aetiology of tinea corporis is very heterogeneous. In several countries in central, southern, and eastern Europe, *M. canis* prevail, while in countries in western and northern Europe, in the USA, and in Latin America (Mexico), *T. rubrum* is the main aetiological agent. In UK and in the USA the anthropophilic species *T. tonsurans* is the second most common pathogen of tinea corporis after *T. rubrum*. Tinea corporis was more common in children than in adults, as reported by others.

*Tinea unguium* and tinea pedis ranked second and third in prevalence and have been dominated by *T. rubrum*, which reached 69.4% and 54.2% of the isolated strains, respectively. Our findings are in accordance with previous studies from the island of Crete, studies from other parts of Greece, as well as similar reports from other developed countries worldwide.

The feet are particularly prone to dermatophytoses because they are the anatomic structures in the most contact with the environment, where infective structures of dermatophytes may remain viable for years. According to Achilles project, the largest survey on foot disease conducted in 20 European countries, tinea pedis and tinea unguium are the most frequently observed fungal infections.

Feet and toenails are an important reservoir from which fungal infections could spread to other body sites. Onychomycosis is the most common infective nail disorder accounting for about 50% of all consultations for nail disorders. Males were more frequently affected than females, and tinea unguium was more prevalent in the elderly. According to Gupta and colleagues, the gender difference may be due to differences in hormone levels that result in a different capacity to inhibit dermatophyte growth. Several studies have shown that there is a correlation between age and onychomycosis. Onychomycosis increases steadily with age. This may be attributed to slow-growing nails, reduced peripheral circulation, diabetes mellitus, nail trauma, increased exposure to disease-causing fungi, and immunosuppression.

*Tinea capitis* continues to be an important health problem in Crete, affecting mainly preschool and school children. In the current study tinea capitis constituted 12.5% of all tineas and mainly occurred in the age group < 15 years. *M. canis* predominated as an aetiological agent (94.3%), followed by *T. mentagrophytes*. The incidence of tinea capitis varies by gender, depending on the infecting organism. When the causative agent is *M. canis*, the infection rate in boys is usually higher. Tinea capitis is mostly caused by *M. canis* worldwide and also in Europe and most especially in the Mediterranean area. It is noteworthy that there is a shift towards the anthropophilic tineas in Europe, mainly due to high immigration.
idence of tinea capitis due to *T. violaceum* increased considerably over the last decades due to the immigration wave, mainly from Albania. *T. violaceum* cases of tinea capitis are increasingly reported in Sweden, Barcelona and Madrid in Spain, Italy, and Switzerland; *T. tonsurans* in UK, France, Netherlands, Spain, and Ireland; and *Microsporum audouinii* in Germany, UK, France, and Belgium.

Ringworm of the face accounted for 8.6% of all dermatophytoses. Almost half of the cases were diagnosed in children under 15 years of age, with a peak between 2 and 12 years. Tinea faciei is observed more frequently in children as a result of contact with domestic and stray animals, such as cats and dogs. In the present study, the zoophilic species *M. canis* followed by *T. mentagrophytes* accounted for the majority (75%) of the isolates, and in 61% of these cases, close contact with animals (mainly cats) was reported, as described by others. Similar to other studies, males were more frequently affected than females. In the present study, the zoophilic species *M. canis* followed by *T. mentagrophytes* accounted for the majority (75%) of the isolates, and in 61% of these cases, close contact with animals (mainly cats) was reported, as described by others. The aetiological agent of tinea faciei varies according to geographic region. In Northern Greece and Italy, *M. canis* is the predominant agent; in Spain and in Switzerland (Zurich area), *T. mentagrophytes*; in Iran, *T. verrucosum*; in the USA, *T. tonsurans*, *T. rubrum*, and *M. canis*; and in Sweden, *T. violaceum*.

Tinea cruris accounted for 3.9% of all dermatophytoses. Similar to other studies, *T. rubrum* was the predominant aetiological agent followed by *T. mentagrophytes*. Adults were much more commonly affected than were children. Risk factors for ringworm of the groin include wearing tightly-fitting or wet clothing for extended periods, sharing clothing with others, or coexisting diabetes mellitus or obesity.

Tinea manuum was the least common clinical presentation. *T. rubrum* and *T. mentagrophytes* were the most commonly isolated species. This is in accordance with our previous studies from Crete, Greece, and other countries worldwide. Males were more frequently affected than females, possibly due to their increased involvement in outdoor activities.

The highest prevalence of *M. canis* and *T. mentagrophytes* infections was registered in fall, while *T. rubrum* infections showed a peak in summer and winter. With regard to seasonality, Iorio et al. found that *M. canis* infections occurred more frequently in the warm seasons, investigated tors from India observed higher incidence of dermatophytoses in summer, while others from Iran detected a rise in their incidence in winter and fall due to the lower temperature and the higher humidity. Continuing studies on dermatophytoses will improve our knowledge on the epidemiology of these infections in our area, which is expected to further change in the future as a result of mass tourism, migration, climatic variations, and changes in population demographic characteristics and lifestyle practices.

**Declaration of interest**

The authors report no conflicts of interest. The authors alone are responsible for the content and the writing of the paper.

**References**

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