J. Hyg., Camb. (1978), **80**, 301
Printed in Great Britain

Geographical distribution of the dermatophytes: a review

By CHRISTINE M. PHILPOT

Mycological Reference Laboratory of the Public Health Laboratory Service, London School of Hygiene and Tropical Medicine, Keppel Street, London WC1E 7HT

(*Received* 16 *August* 1977)

INTRODUCTION

In these days of rapid transit from continent to continent, and the increasing mobility of people, agents of disease are no longer geographically restricted. Disease contracted half way across the world may become manifest in a country in which the pathogen is not normally found. Thus knowledge of the geographical distribution of pathogens becomes increasingly important when a diagnosis is being made. This is as true of ringworm fungi as of any other group of micro-organisms. In the last 12 years, in the Mycological Reference Laboratory, an increasing number of exotic dermatophytes have been seen, related in part at least to the great increase in the number of non-British residents.

Not all species of dermatophytes are cosmopolitan in their distribution throughout the world. While some have been recorded from every continent, others have geographically limited areas of greater or lesser extent. Surveys taken at intervals in a country may show a rise and fall in occurrence of several species as habits change, populations move and medical facilities became increasingly well-distributed.

There have been few geographical surveys of ringworm fungi that have covered the world. Ajello (1960, 1974) has reviewed the individual species with regard to geographical location, while Vanbreuseghem & de Vroey (1970) attempted to estimate the relative importance of the various species in terms of numbers of isolations reported. This paper therefore reviews the world dermatophyte flora in terms of the dominant agents in the various countries, and some of the changes that have been recorded.

EUROPE

In Great Britain the dominant agent of tinea capitis in 1945 was *Microsporum audouinii* (Duncan, 1945). It was recorded particularly in the Midlands and north of the country (Carlier, 1963). In the south, especially in Devon and Cornwall, there were local pockets of *M. canis*. Three cultural varieties of *M. canis* were recognized and each had its distinctive area. The main agent of tinea pedis was *Trichophyton mentagrophytes* var. *interdigitale*. *T. rubrum*, on the contrary, was regarded as a rare exotic pathogen (Duncan, 1945; Carlier, 1963). Since then tinea capitis has declined in importance: Murray (1966) estimated the prevalence of *M. canis* and *M. audouinii* as 3·7 and 1·1 % respectively, and this has remained fairly constant since then. *T. verrucosum* was the most important species of *Tricho-*

Table 1. *Geographical distribution of the dermatophytes and the normal host*

	Geographical area	Normal host
Anthropophilic		
Microsporum audouinii	Cosmopolitan	Man
M. ferrugineum	Asia, Central Africa, S. America, E. Europe	Man
Trichophyton mentagrophytes var. *interdigitale*	Cosmopolitan	Man
T. rubrum	Cosmopolitan	Man
T. schoenleinii	Cosmopolitan	Man
T. violaceum	Cosmopolitan	Man
T. tonsurans	Cosmopolitan	Man
T. soudanense	N. Central Africa	Man
T. megninii	Europe	Man
T. concentricum	Pacific, Asia, Americas	Man
T. gourvilii	West Africa	Man
T. yaoundei	Cameroun, Congo	Man
Epidermophyton floccosum	Cosmopolitan	Man
Zoophilic		
Microsporum canis	Cosmopolitan	Dog, Cat
Trichophyton mentagrophytes var. *granulare*	Cosmopolitan	Various, esp. rodents
T. gallinae	Cosmopolitan	Poultry
T. verrucosum	Cosmopolitan	Cattle
T. equinum	W. Europe, Americas	Horse
T. simii	India, U.S.A.	Monkey
T. erinacei	UK, New Zealand	Hedgehog
Microsporum persicolor	Europe, USA	Vole
M. distortum	USA, New Zealand	Dog, monkey
Geophilic		
*Microsporum gypseum**	Cosmopolitan	Soil
M. cookei	Europe, USA	Soil
Trichophyton ajelloi	Cosmopolitan	Soil
T. terrestre	Cosmopolitan	Soil

* Occasionally pathogenic.

phyton isolated from tinea capitis, although there were a small proportion of cases caused by non-indigenous species presumably brought in by immigrants and travellers abroad. Since 1945 *T. rubrum* has become an extremely common cause of tinea in all parts of the body except the scalp. It is believed that this fungus was introduced into this country by soldiers returning from service in the Far East; new importations from abroad helped to spread the infection (Walker, 1950). There is evidence, however, that *T. mentagrophytes* causes a greater number of ringworm lesions. Since it produces less obvious discomfort and deformation, it is less often seen in the dermatological clinic unless a particular effort is made to screen for it (English, 1976). *Epidermophyton floccosum*, and in the country, *T. verrucosum*, are the other main agents of ringworm isolated.

In Northern Ireland (Mackenzie & Rusk, 1964) the main species are animal types: *T. verrucosum* and *M. canis*. *M. audouinii*, an important agent of scalp ringworm in 1953 (Beare & Cheeseman, 1953) is now rarely recorded. *T. tonsurans* is still

Table 2. *Geographical distribution of the dermatophytes: dominant pathogens of Europe and Middle East*

Area	Tinea capitis	Tinea corporis	Tinea pedis
Great Britain	*M. canis*	*T. rubrum*	*T. rubrum* *T. mentagrophytes*
Ireland	*M. canis* *T. verrucosum* *T. tonsurans*	*T. verrucosum*	*T. mentagrophytes*
Western Europe	*M. canis*	*T. rubrum*	*T. rubrum* *T. mentagrophytes*
Portugal	*T. violaceum*	*T. violaceum* *T. tonsurans* *M. canis*	*T. mentagrophytes*
Spain	*T. violaceum* *M. canis*	*T. violaceum* *T. mentagrophytes*	*T. mentagrophytes*
Italy	*T. violaceum*		
Greece	*T. violaceum* *M. canis*	*M. canis* *T. rubrum* *T. mentagrophytes*	*T. mentagrophytes*
Eastern Europe	*T. violaceum*	*T. mentagrophytes*	*T. mentagrophytes* *T. rubrum*
Israel	*T. violaceum*	*T. rubrum*	
Kuwait	*M. canis*		
Lebanon	*T. violaceum*	*E. floccosum*	*T. rubrum* *T. mentagrophytes*
Iran Iraq Turkey	*T. schoenleinii*		

endemic but has decreased in importance since 1959 (Fleming, 1975). A similar picture holds true for Eire (Buckley & Foley, 1968).

In northern and western Europe the same species as in the United Kingdom are found, and the picture has been the same: a decrease in *M. audouinii* since the end of World War II and an increasing predominance of *T. rubrum* (Blaschke-Hellmessen, Haufe & Seebacher, 1975). In France a decline from 80 to 50% for *M. audouinii* was accompanied by an increase in *M. canis* from 10–50% (Coudert, Battesti, Despeignes & Ambroise-Thomas, 1965). But as one moves south and east the picture begins to change (Pena Yanez, 1960; Pinetti, 1959; Feinstein, Ziprkowski, Sommer & Harari, 1971). The most important agent of scalp ringworm all round the Mediterranean and in Eastern Europe is *T. violaceum* (Johanny, 1964; Ziprkowski & Sommer, 1969; Vilanova, Casanovas & Lecha, 1959). In Portugal. (Neves, 1960; Neves & Carmen-Sousa, 1960), *T. megninii* is relatively common but is rarely encountered elsewhere. However, a report from Greece (Marcelou-Kinti, Papageorgiou, Papavissiliou & Capetanaki, 1973) indicated that during the 1960s there was a decline in the frequency of *T. violaceum* from 72 to 5%. In contrast scalp ringworm due to *M. canis* increased from 19 to 88%. *M. canis* was also

responsible for the greater proportion of tinea corporis, but as in Western European countries *T. rubrum* and *T. mentagrophytes* were the most important agents of nail and foot infections. In Eastern Europe *T. violaceum* and *T. schoenleinii* (the agent of favus) were most commonly isolated from scalp infections, although *M. audouinii* was reported to be predominant in Serbia and Roumania (Kachnic, 1967; Grin & Ozegovic, 1964; Alteras & Cojocaru, 1970). *M. ferrugineum*, regarded as predominantly a pathogen of Asia and Central Africa, is found in Eastern Europe, and is thought to have been introduced by soldiers returning from the Far East (Ajello, 1960). In Roumania its introduction is credited to immigrants from Korea (Alteras & Cojocaru, 1970). Favus is endemic in Eastern Europe and has been considered to be an important health problem in Iran and Iraq; a survey in Baghdad (Rahim, 1966) showed that children between the ages of 5 and 10 years were most frequently affected and males were more susceptible than females. Ardehali (1973) reported that *T. schoenleinii* was the most important cause of nail infection in Iran. A survey of primary school children in Kuwait (Selim & Al-Shazely, 1973) indicated that 76% of all infections were due to *M. canis* and only 10% to *T. violaceum*. Throughout Europe surveys have recorded a decrease in anthropophilic infections (due to species with man as the only host) with the exception of *T. rubrum*, but an increase in the number due to zoophilic *T. mentagrophytes* and *T. verrucosum*.

ASIA

One of the most extensively surveyed areas in terms of the number of papers on epidemiology of ringworm is the Indian subcontinent and adjacent areas. For examples, surveys have been carried out in North India, Delhi, Burla, Bangalore, Calcutta, Poona, Hyderabad, Lucknow, Madras, Karachi, and Bangkok (Alam & Muazzam, 1974; Bhushanam, Singh & Patnaik, 1972; Dasgupta, Agarwal & Bedi, 1975; Dasgupta & Shome, 1959; Gugnani, Mulay & Murty, 1967; Klokke & Durairaj, 1967; Kalra, Mohapatra & Gugnani, 1964; Nath & Agarwal, 1971; Pankajalakshmi & Subramanian, 1974; Panda, Mohanty, Mohanty & Nanda, 1967; Indira, Sirsi & Kristnamurthi, 1971; Taylor, Kotrajaras & Jotisankasa, 1968). In India and Asia generally, *T. violaceum* is the main cause of scalp ringworm (84% reported from Pondicherry) although *M. ferrugineum* is predominant in China and Japan (Khan & Anwar, 1968; Desai, 1966). However, many surveys report very little tinea capitis, whereas tinea corporis appears to be much more important. It has been suggested that the extensive use of hair oil helps to prevent the establishment of fungi on the scalp. A survey in Poona (Padhye & Thirumalachar, 1968) indicated that tinea pedis was common in the rainy season in patients walking barefoot on moist floors, but was also found in summer in patients wearing socks and shoes. Tinea corporis was more common in the adult male. In females, tightness of saris around the waist provided constant irritation and sweating; 80% of female infections were in the waist area. *T. rubrum* is the main cause of tinea corporis in India; a survey in 1966 (Desai, 1966) recorded an incidence of 53% in adults and 14% in children, and these percentages dropped only

Table 3. *Geographical distribution of the dermatophytes: dominant pathogens of Asia and Australasia*

Area	Tinea capitis	Tinea corporis	Tinea pedis
Thailand		*T. rubrum* *T. mentagrophytes*	*T. rubrum* *T. mentagrophytes*
India	*T. violaceum*	*T. rubrum*	*T. mentagrophytes* *T. rubrum*
Bangladesh		*T. rubrum*	
China and Japan	*M. ferrugineum*		
Hongkong	*M. canis*	*T. rubrum*	*T. rubrum*
Malaysia	*M. canis*		*T. mentagrophytes*
Philippines	*T. violaceum*		
Pacific Islands		*T. concentricum* (*T. rubrum*)	
Australia	*M. canis* (*T. violaceum*)	*M. canis*	*T. mentagrophytes* *T. rubrum*
New Zealand	*M. canis*	*M. canis*	*T. mentagrophytes* *T. rubrum*

slightly when further groups were examined. The highest incidences occurred between the ages of 15 and 40 years.

AUSTRALASIA

In Australasia tinea capitis, at least among the white population, is caused predominantly by *M. canis* in children (Ridley, Wilson & Harrington, 1961) but *T. tonsurans* has been recorded more often from adults. A survey in South Australia (Donald, Shepherd & Brown, 1959) recorded an incidence of infections due to *T. violaceum* approaching that found in North Africa, but these were found mainly in the aboriginal population. A later survey in the same area (Donald, Brown & Shepherd, 1965) showed that *T. tonsurans*, found more often in aborigines than whites, was distributed all over the province, whereas *T. violaceum*, also isolated from aborigines, was usually encountered among the aborigines living near the coast where there was more contact with whites. It was also recorded in Greek and Italian immigrants; from such a source presumably it had spread into the native population. A recent survey of the aboriginal population of the Northern Territories (Green & Kaminski, 1973) showed that an eczematous form of *T. rubrum* infection was endemic in the population. *T. tonsurans* was found in the arid areas but the two species apparently did not co-exist. *M. audouinii* has not been recorded in Australia and is extremely rare in New Zealand; it is thought that it is introduced periodically into New Zealand by immigrants but the infection does not spread, possibly because it is prevented by *M. canis*. The population is however small and thinly spread (Marples, 1959) and *M. audouinii* is particularly a species causing epidemics in crowded communities. *M. distortum* is found sporadically in New Zealand; this species is considered to be an aberrant form of *M. canis*. *T. mentagrophytes* is the most common cause of tinea pedis, but an increase in the

number of cases due to *T. rubrum* has been reported especially in the North Island.

The typical form of ringworm in the Pacific Islands is a distinctive clinical entity called tinea imbricata from the overlapping scales in the infected area. The causal agent is *T. concentricum*. A survey conducted in the Solomon Islands in 1950 (Marples, 1950) among children recorded an incidence of ringworm of 6 %; tinea versicolor, a superficial yeast infection, occurred in about 12 % of patients. There was a complete absence of scalp ringworm although many children had scalp impetigo. It was considered possible that this might prevent the growth of fungi. Alternatively the widespread use of hair oil might also have an inhibitory influence. The most common site was the back, followed by the chest, face and neck, the legs and arms being less frequently affected. A later survey (Smith & Marples, 1964) showed 72 % of cases due to *T. concentricum* and 25 % to *T. rubrum* (particularly adults and adolescents). There are differences, however, between the various Pacific Islands, since *T. rubrum* is predominant in Tokelau, Cooke Islands and Western Samoa. In the New Hebrides, *T. concentricum* and *T. rubrum* are found in equal incidence (Marples, 1968). The only *Microsporum* species found was *M. gypseum*, from the soil; the other species apparently are not represented in the Pacific.

THE AMERICAS

In South America generally, *M. canis* is the commonest agent of scalp ringworm; in Chile, it has been recorded in 71 % of all infections (Zaror, 1974). In Central America it is replaced by *T. tonsurans* (Gonzalez-Ochoa & Gonzalez-Mendoza, 1960; Gonzalez-Ochoa & Victoria, 1974). The most extensive survey has been carried out in Brazil (Londero, 1962, 1963, 1964) mainly in the south of the country. *M. canis* is the dominant agent of tinea capitis and tinea corporis in urban areas: a feature of the survey was the large number of cases recorded in children under five. The fungus has, however, not been recorded north of Pernambuco. *T. mentagrophytes* was the dominant species isolated from tinea pedis, mainly in adults, and *T. rubrum* was isolated predominantly from cases of tinea cruris. Favus was recorded mainly from young children and is limited geographically to the southern part of the country. *T. schoenleinii*, the agent of favus, was apparently introduced into Brazil by Italian immigrants, and they are also credited with the introduction of *T. violaceum* into São Paulo and the states to the east and north. Surprisingly, *T. concentricum* is endemic among the Indians of the Bolivian frontier. This fungus has also been recorded from central and north America but its main area is regarded as the Pacific, which suggests interesting possibilities into the manner in which it reached the American continent. *M. ferrugineum* has been recorded from Minas Gerais. *T. tonsurans* is also limited geographically, being found only in the north above latitude 15° S; it is dominant in the Amazon area.

A survey in Puerto Rico, in the Caribbean (Carrion, 1965) for the years 1930–49 indicated that tinea pedis, followed by nail and body infections were far more common than scalp ringworm. *T. mentagrophytes* and *T. rubrum* together

Table 4. *Geographical distribution of the dermatophytes: dominant pathogens in the Americas*

Area	Tinea capitis	Tinea corporis	Tinea pedis
USA, Canada	*M. canis* *T. tonsurans* *M. audouinii*	*T. rubrum* *T. mentagrophytes*	*T. mentagrophytes* *T. rubrum*
Puerto Rico	*T. tonsurans*	*T. mentagrophytes*	*T. mentagrophytes* *T. rubrum*
Mexico	*T. tonsurans*	*T. tonsurans* *T. rubrum* *T. mentagrophytes*	*T. mentagrophytes* *T. rubrum*
Venezuela	*T. tonsurans* *M. canis*	*T. mentagrophytes* *T. rubrum*	
Peru	*T. tonsurans*		
Brazil	*T. violaceum* *T. tonsurans* *M. canis*	*M. canis*	*T. mentagrophytes*
Uruguay	*M. canis*	*M. canis*	*T. mentagrophytes*
Argentina	*M. canis*		
Chile	*M. canis*		

accounted for over 70% of all the cases seen. Tinea capitis was due mainly to *T. tonsurans*, as in Central America.

A survey in the Montreal area of Canada for 1963–73 (Dion & Kapica, 1975) showed that there had been a significant decrease in the proportion of endothrix and favic infections. Favus has never been reported from Newfoundland (Ross, Butler, Cross & Fardy, 1971). Only 4% of scalp ringworm was reported, due mainly to *M. canis*. *T. rubrum* accounted for 23% of all cases of tinea seen, but is said to be much less common in Alberta and Newfoundland (Ross *et al.*, 1971), whereas in British Columbia it reaches a level of around 46%. *T. rubrum* is also common across the border in New York State (Saunders, 1973). In the United States, a changing pattern of ringworm infection of the scalp has been seen in the last five decades (Gaisin, Holzwanger & Leyden, 1977). Before the Second World War *M. canis*, and to a lesser extent *T. mentagrophytes*, were the main causes, but in the 1930s and 1940s *M. audouinii* spread rapidly across the States. It was the cause of large scale epidemics among schoolchildren, as in the United Kingdom (Bocobo, Eadie & Miedler, 1965). However, in the early 1950s *T. tonsurans* began to be isolated more frequently, firstly in the southern states, having been brought in by itinerant workers from Mexico (Georg, 1952; Hand & Georg, 1955). It followed their movements north and east, until today it is an important, even dominant, agent of tinea capitis in parts of the northeast (Gaisin, Holzwanger & Leyden, 1977).

Table 5. *Geographical distribution of the dermatophytes: Africa*

Area	Tinea capitis	Tinea corporis	Tinea pedis
Morocco	*T. violaceum* *T. schoenleinii*		
Tunisia	*T. violaceum*		
Algeria	*M. canis* *T. schoenleinii* *T. violaceum*	*T. rubrum*	*T. rubrum* *T. mentagrophytes*
Egypt	*T. tonsurans*		
Fr. Guinea	*M. audouinii* *T. soudanense*	*T. soudanense*	
Liberia	*T. soudanense*		
Senegal	*T. soudanense*	*T. soudanense*	
Nigeria	*M. audouinii* (*T. soudanense*)	*T. rubrum*	
Sudan	*T. violaceum* *M. canis* *T. soudanense*		
Somalia	*T. violaceum* *T. soudanense*	*T. soudanense*	
Chad	*T. soudanense*		
Portuguese W. Africa	*M. ferrugineum*		
Zaire (Belgian Congo)	*M. ferrugineum* *T. violaceum* *M. audouinii*		
Katanga	*M. audouinii* *T. violaceum*		
Kenya	*T. violaceum* *M. ferrugineum*	*M. ferrugineum*	
Tanzania	*T. violaceum*	*T. rubrum*	
Zambia	*T. violaceum* *M. audouinii*	*T. verrucosum* *T. mentagrophytes*	
Angola	*T. violaceum*	*T. rubrum*	*T. rubrum*
Rhodesia	*T. violaceum* *M. canis*		
Malawi	*M. audouinii*		
Mozambique	*M. ferrugineum*		
South Africa:			
Transvaal	*M. canis* *T. violaceum*	*M. canis*	*T. mentagrophytes*
Natal	*T. violaceum*	*T. rubrum*	*T. rubrum*
Cape Province	*T. violaceum*	*T. mentagrophytes*	*T. mentagrophytes*

AFRICA

Africa has been particularly well-covered by surveys, especially in former French and Belgian territories (Andrieu *et al.* 1962; Basset & Basset, 1960, 1961; Brede, 1962; Brinkman, 1974; Clarke & Walker, 1953; Da Fonseca, Neves &

Figueiredo, 1964; Findlay, 1959, 1974; Juminer, Rioux & Stefanovic, 1964; Nsanzumuhire & Masawe, 1974; Pattyn & Sassen, 1960; Verhagen, Maniar & Vanbreuseghem, 1969; Vanbreuseghem, 1957, 1966*a*, 1966*b*, 1968). Most surveys have concentrated on tinea capitis and it has been estimated that 20 million Africans suffer from this sort of ringworm; the number of carriers increases the figures (Verhagen, 1974). It is an important disease because of the social stigma attached to it, the possibility of scarring and balding and the secondary diseases associated with ringworm. Africa has a very varied flora since it stretches from one Mediterranean area in the north to a similar climate in the south, with tropical and desert areas in between. Verhagen has divided the types of fungi causing tinea capitis into two groups: those limited in area but causing large scale epidemics, such as *T. soudanense*, *T. violaceum*, *T. schoenleinii*, *M. ferrugineum*, and *M. audouinii*; and those universally found but causing only small scale outbreaks, such as *T. mentagrophytes* and *T. tonsurans*. One of the most fascinating aspects of all these surveys is the light they shed on the distribution of certain of the dermatophytes. *T. violaceum*, which is the commonest agent of tinea capitis in North Africa including Egypt (Mofty, Jeffries & El Komy, 1968), is not found in West Africa or in Central Africa in the lowlands south of Chad, but it is recorded in the cooler parts of the continent from the East Africa highlands, the Congo highlands and South Africa. Its limits coincide with Arabic, Amharic and Swahili languages, a link with the Middle East. *T. schoenleinii* is also not found in Central Africa but is recorded from South Africa, and northwards from Lake Chad and the Sahara in North Africa to the Arabic Middle East. It has been suggested that the distribution of these two species is a reflection of the age-old trading contact that these areas have had with the Middle East and the north coast of Africa. *T. soudanense* is a species of tropical lowlands and semi-arid areas across the middle of Africa from Senegal to Somalia. In the Sudan it is found only in the southern part of the country (Mahgoub, 1965). *M. ferrugineum* is found in Central Africa, predominantly in Zaire and spreads westwards to Nigeria and eastwards into Kenya and Uganda. It is, however, rare east of the Rift Valley. Its distribution suggests that it may be indigenous in these areas. *T. rubrum* is not commonly found in South Africa or the Congo area, but it accounts for about 5% of cases in Kenya and is the most common cause of tinea corporis in Nigeria. *M. audouinii* is also rare in South Africa, although one survey in Mozambique has reported a 60% infection rate due to this species (Brede, 1972), but it is otherwise distributed right across West and Central Africa to Mozambique and Tanzania. It is predominant in Mozambique, Katanga and Nigeria. *M. canis* is found in North Africa, and in South Africa, but is rarely reported from elsewhere. *T. yaoundei*, first reported from the Congo and Central Equatorial Africa, has recently been reported from South Africa (Young, 1976), and may be expected to be found in other areas.

A vertical distribution of species has also been reported by some workers in Africa. In Kenya (Verhagen *et al.* 1969) and Somalia (Vanbreuseghem, 1966*a*), *T. violaceum* was found in areas over 500 m in altitude while *T. soudanense* became increasingly important in the coastal lowlands. In Zaire (formerly the Congo) (Vanbreuseghem, 1957), *Microsoporum* species were found in the lower parts of

the country and *Trichophyton* species in the mountainous areas especially of Ruanda-Urundi where they accounted for all the cases of tinea capitis seen.

There have been far fewer surveys on the incidence of other types of ringworm in Africa. Apart from the countries where the dominant scalp pathogen seems also to cause a large proportion of body ringworm e.g. *T. soudanense* in French Guinea, Senegal, and Somalia and *M. canis* in the Transvaal, the main agents of both tinea corporis and tinea pedis seem to be *T. rubrum* and *T. mentagrophytes*, as in the other continents.

Tables 1–5 summarize the data obtained from the various surveys. Although much is known of the geographical distribution and habitats of the ringworm fungi, it is obvious that there are gaps in the knowledge, and need for more extensive surveys in many parts of the world.

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