Dermatophytosis

Ringworm, Tinea,

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Importance

Dermatophytosis is a common contagious disease caused by fungi known as dermatophytes. Dermatophytes belong to a group of organisms that are able to break down the keratin in tissues such as the epidermis, hair, nails, feathers, horns and hooves. Most of these fungi reside in the soil and are involved in decomposition; however, the dermatophytes can infect living hosts. Some dermatophytes (anthropophilic species) are adapted to humans, and are usually transmitted from person to person. Others (zoophilic species) are adapted to animals. A few (geophilic) species normally live in the environment, but occasionally act as parasites. The zoophilic and geophilic species are sometimes transmitted from animals to people. It is also possible for humans to transmit anthropophilic dermatophytes to animals, although this seems to be uncommon.

In living hosts, dermatophytes usually remain in superficial tissues such as the epidermis, hair and nails. Serious consequences are uncommon and infections can be self-limiting. However, the illness may be disfiguring and uncomfortable, especially when the lesions are widespread. Economic effects, such as damage to hides, are also important in livestock. Infrequently, dermatophytes may invade subcutaneous tissues and (very rarely) other sites, especially in immunocompromised hosts.

Etiology

Dermatophytosis is caused by pathogenic, keratin-digesting fungi in the genera *Microsporum, Trichophyton* and *Epidermophyton*. Members of *Microsporum* and *Trichophyton* cause illness in both humans and animals. *E. floccosum* is the only species of *Epidermophyton* known to cause disease, and it usually affects only people. Some authors use the term "dermatophytoids" for soil-dwelling members of *Microsporum, Trichophyton* and *Epidermophyton* that are never or rarely associated with disease (e.g., *T. terrestre*).

Dermatophytes, like many fungi, may have two different species names. One name belongs to the asexual form (the anamorph state), which is the form that occurs in vertebrate hosts. The other name is given to the sexual state of the organism. The latter form, called the teleomorph form or the "perfect state," is produced by mating between anamorphs. For example, the dermatophyte *Microsporum canis* infects animals; however, when this organism mates with a compatible environmental organism, the resulting sexual form is called *Arthroderma otae*. The teleomorph (perfect) states of both *Microsporum* and *Trichophyton* belong to the genus *Arthroderma*, and dermatophytes known to have sexual states are placed in the phylum Ascomycota, family Arthrodermataceae. Dermatophytes that currently have no known sexual state, like other medically important fungi with this characteristic, are classified as Deuteromycota (Fungi Imperfecti).

Although dermatophytes originated from soil-dwelling keratinophilic organisms, only a few pathogenic species still reside primarily in this niche. These organisms, known as geophilic dermatophytes, are associated with decomposing keratin sources in the environment. *M. gypseum* and *M. nanum* are the only two geophilic dermatophytes that are important pathogens in animals. *M. gypseum* is also seen in people, but *M. nanum* occurs infrequently.

Most species that cause dermatophytosis have become adapted to people or animals, and are now maintained in these reservoirs. Although they can infect other hosts, each dermatophyte tends to be associated with a particular host or group of hosts, and it is not maintained in other species long term. Zoophilic dermatophytes are adapted to various animal species, while anthropophilic dermatophytes occur in humans.

Zoophilic *Microsporum* species include *Microsporum canis*, *M. gallinae* and *M. persicolor*. Most sources no longer use the name *M. equinum* for the organisms found in horses, but consider them to be equine-adapted *M. canis*. Zoophilic members of *Trichophyton* include *Trichophyton equinum*, *T. bullosum*, members of the *T. mentagrophytes* complex, *T. simii* and *T. verrucosum*. Most or all zoophilic dermatophytes are thought to be zoonotic, although some are transferred to people more often than others.

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There are numerous species of anthropophilic dermatophytes, including *T. tonsurans*, the *T. rubrum* complex, *T. violaceum*, *T. mentagrophytes* var. *interdigitale*, *T. soudanense*, *T. schoenleinii*, *M. audouinii*, *E. floccosum* and others. Although anthropophilic dermatophytes can be transmitted to animals, this seems to be rare.

The predominant dermatophytes involved in human cases vary with the climate, geographic location and other factors such as exposure to livestock, pets or exotic species. Zoophilic dermatophytes can be a common cause of a syndrome in one region, while anthropophilic dermatophytes account for most cases in another. The causative agents can also change over time, with some species becoming less common (e.g., due to the introduction of effective treatments or changes in exposure) and others becoming more prevalent.

Dermatophyte taxonomy

The taxonomy of the dermatophytes, particularly members of *T. mentagrophytes*, is controversial. Organisms may be assigned different names depending on whether the source is using traditional identification methods or genetic typing.

Diagnostic laboratories have traditionally identified dermatophytes based on their colony and microscopic morphology, nutritional and biochemical characteristics, and other factors. Such methods, together with the ecology of an organism (e.g., its adaptation to a particular host) have given rise to a number of species names. However, some organisms that appear to be different species, based on conventional typing and/or ecology, may be very closely related genetically. Furthermore, the traditional typing methods have given rise to a situation where a single anamorph can have two different teleomorphs, suggesting that such "species" actually contain more than one species.

A taxonomic method first proposed in 1999 defines dermatophyte species by genetic techniques, specifically the sequencing of highly variable internal transcribed spacer (ITS) regions of the ribosomal DNA. Some authors have adopted the ITS scheme. Others feel that its adoption is premature and based on limited data. ITS taxonomy has been criticized because it may place organisms into the same species even when they seem to be ecologically distinct based on their adaptation to different hosts; zoophilic, anthropophilic or geophilic nature; or distinctive characteristics such as opposite mating types or ability to penetrate hair *in vitro*. In addition, the results of ITS typing may not agree with the results of genetic analyses based on other genes. Some sources also use traditional typing schemes for practical reasons: genetic typing is not widely used in diagnostic laboratories, and some species defined by ITS sequencing can be difficult or impossible to identify by conventional methods. This is especially true for *T. mentagrophytes*.

Zoophilic or geophilic species that have new names, under the ITS genetic system, include the following:

- Horse-adapted isolates of *M. canis*, which do not perforate hair in *in vitro* tests (unlike most *M. canis*) and produce few conidia, were formerly called *M. equinum*. Based on genetic relatedness, they are now considered to be *M canis*.
- The organism known as *M. gypseum* in the traditional taxonomy contains both *M. gypseum* and *M. appendiculatum* in the ITS system.
- The species *M. gallinae*, a zoophilic organism found in birds, includes the geophilic organism *M. vanbreuseghemii* in the ITS system.
- *T. verrucosum* varieties have been eliminated under the current ITS genetic taxonomy, and this organism is redefined to include only the species adapted to cattle. The ITS system reassigns *T. verrucosum* var. *autotrophicum*, which occurs in sheep, to *T. interdigitale*.
- The ITS system made major changes in the taxonomy of *T. mentagrophytes*. In traditional taxonomy, zoophilic and anthropophilic isolates of *T. mentagrophytes* can be separated, in part, by their different colony morphologies on primary isolation. The species *T. mentagrophytes* var *interdigitale* is anthropophilic in this system, and mainly contains isolates associated with tinea pedis (athlete's foot) and infections of the nails. Under the ITS taxonomy, however, most of the organisms that previously belonged to *T. mentagrophytes* were placed in this variety, and it was elevated to the level of a species (*T. interdigitale*). Thus, *T. interdigitale* in the ITS system includes both anthropophilic organisms (the former *T. mentagrophytes* var. *goetzii*, *T. mentagrophytes* var. *interdigitale*, *T. mentagrophytes* var. *nodulare* and *T. krajdenii*) and zoophilic organisms, including the former *T. mentagrophytes* var. *mentagrophytes*, *T. mentagrophytes* var. *granulosum* and *T. verrucosum* var. *autotrophicum*. Under this system, *T. mentagrophytes* still contains the former *T. mentagrophytes* var. *quinckeanum* and two camel-associated species, *T. langeronii* and *T. sarkisovii*. In addition, the authors of the ITS scheme suggest that all three of these species are associated with camels, although *T. mentagrophytes* var *quinckeanum* was previously linked mainly with mice. The association of the latter organism with camels has been disputed, and the entire reorganization of *T. mentagrophytes* is controversial.

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- Two other varieties of *T. mentagrophytes* received new names in the ITS system. *T. mentagrophytes* var. *erinacei*, which is adapted to hedgehogs, is now considered to be the species *T. erinacei*. In addition, isolates of *T. mentagrophytes* found mainly in guinea pigs (which were usually identified as *T. mentagrophytes* var. *granulosum*) are now called "the *Trichophyton* anamorph of *A. benhamiae."* This anamorph was not given a separate species name. Although it is sometimes shortened to "*A. benhamiae"* in clinical literature, the *A. benhamiae* complex also contains several other organisms (e.g., *T. erinacei*, *T. verrucosum* and the anthropophilic organism *T. concentricum*).

It should be noted that species names, as currently defined under the ITS genetic taxonomy, may change in the future. For instance, *T. equinum*, which is adapted to horses, was reassigned to the anthropophilic species *T. tonsurans* at one time; however, it was later acknowledged to be a different species.

This factsheet generally uses the traditional taxonomy.

Geographic Distribution

Dermatophytes grow best in warm and humid environments and are, therefore, more common in tropical and subtropical regions. Their distribution varies with the organism. *M. canis*, *M. nanum*, *M. gypseum*, *T. mentagrophytes*, *T. verrucosum* and *T. equinum*, occur worldwide, although their prevalence varies with the region. *T. simii* was thought to be endemic only in Asia, specifically the Indian subcontinent; however, infections acquired in Europe and Africa suggest that its distribution might be more widespread.. *T. mentagrophytes* var. *erinacei* (*T. erinacei*) is associated with hedgehogs, and it is found where these animals occur in the wild (Europe, New Zealand and Africa), or in countries where they are kept as pets. *M. persicolor* has been reported in Europe, and *T. bullosum* has been detected in Tunisia, Sudan, Syria and France.

Like zoophilic species, anthropophilic dermatophytes may be either cosmopolitan or more limited in their distribution. The latter group may be imported into other countries on infected individuals.

Transmission

People and animals become infected by dermatophytes after contact with spores (conidia). Dermatophytes growing in a vertebrate host normally form only arthrospores (arthroconidia), asexual spores that develop within the hyphae. In the environment (e.g., in laboratory culture), they can also produce microconidia and macroconidia, asexual spores that develop outside the hyphae. Initially, the dermatophyte infects a growing hair or the stratum corneum of the skin. These organisms do not usually invade resting hairs, since the essential nutrients they need for growth are absent or limited. Hyphae spread in the hairs and keratinized skin, eventually developing infectious arthrospores.

Anthropophilic and zoophilic dermatophytes are mainly transmitted between hosts by arthrospores in hairs or skin scales. Other asexual or sexual spores formed by the environmental stages may also be infectious. Fomites such as brushes and clippers are important in transmission. Spores may remain viable in suitable environments for up to 12-20 months, and some spores were also reported to persist for at least a year in salt water. Certain types of spores (e.g., microconidia) might be dispersed by airborne means.

Disinfection

Dermatophyte spores are susceptible to benzalkonium chloride, dilute chlorine bleach (1% sodium hypochlorite), enilconazole (0.2%), formaldehyde and some strong detergents. In one study, a 10% solution of alkyldimetylbenzylammonium chloride prevented the growth of *M. canis* from 97% of contaminated hairbrushes, and Virkon-S® was effective on 87%. Another study found that a preparation containing benzylammonium bromide and ethoxyllauric alcohol was effective against the anthropophilic fungi usually found on swimming room floors. Dermatophytes are also reported to be susceptible to iodophors, glutaraldehyde and phenolic compounds; however, some agents may have limited efficacy in "real life" environmental disinfection.

The mechanical removal of any material containing keratin, such as shed skin and hairs, facilitates disinfection. Vacuuming is considered to be the best method in many cases. Dusting may also be appropriate. After mechanical removal, washable surfaces should be cleaned thoroughly with detergent and water.

Dermatophytes are susceptible to high heat. Moist heat of 121°C, applied for at least 20 minutes, or dry heat of 165-170°C for 2 hours, are reported to be effective.

Infections in Humans

Incubation Period

The incubation period in humans is usually 1 to 2 weeks.

Clinical Signs

Dermatophytes generally grow only in keratinized tissues such as hair, nails and the outer layer of skin; the fungus usually stops spreading where it contacts living cells or areas of inflammation. Many dermatophytes can invade hairs as well as the skin; however, some anthropophilic species such as *E. floccosum* and *T. rubrum* are limited to the skin. Mucus membranes are not affected.

The symptoms of dermatophytosis vary, depending on the infecting organism, affected tissues (e.g., skin, hair or nails) and area of the body. In unhaired (glabrous) skin, the lesions are usually characterized by inflammation that is

most severe at the edges, with erythema, scaling and occasionally blister formation. The central area may clear, resulting in the formation of a classic "ringworm" lesion. In haired areas, the hairs become brittle and areas of alopecia may appear. Dermatophytes acquired from animals or the soil generally produce more inflammatory lesions than anthropophilic dermatophytes (but not all individual cases are highly inflammatory). These infections are also less likely to become chronic than those caused by anthropophilic organisms

In humans, dermatophytoses are referred to as "tinea" infections, and are named according to the area of the body involved. Infections can, however, spread from one area to another. For example, tinea faciei (facial dermatophytosis) in children may result from a tinea capitis (scalp) infection that has spread to the face.

Tinea capitis

Tinea capitis, most often seen in children, is a dermatophyte infection of the hair and scalp. The major organisms involved in this condition vary with the geographic area. *M. canis*, a zoophilic species, is often isolated from tinea capitis cases in continental Europe; however, the anthropophilic dermatophyte *T. tonsurans* is currently responsible for most cases in the U.S. and the U.K. Other anthropophilic organisms, whose importance varies with the region, include *T. violaceum, M. audouinii, T. schoenleinii, T. megninii, T. soudanense* and others. The zoophilic organisms *T. mentagrophytes*, *T. verrucosum*, *M. persicolor* and other species, as well the geophilic organisms *M. gypseum* and (uncommonly) *M. nanum*, have been isolated from some cases.

Tinea capitis is characterized by spreading, scaly, irregular or well-demarcated areas of erythema and alopecia. Some anthropophilic dermatophytes may cause dry alopecic patches with minimal inflammation (sometimes with black dots where the hairs break at the follicle). Zoophilic dermatophytes are more likely to cause inflammatory, and in some cases suppurative, lesions, including .boggy, inflammatory masses called kerions. An anthropophilic species, *T. schoenleinii*, causes "favus," a chronic infection characterized by yellow, cup shaped crusts (scutulae) around the hairs. Untreated cases of tinea capitis can last for a month to several years, depending on host factors and the species of dermatophyte involved.

Tinea corporis

Tinea corporis, or ringworm, occurs on the trunk and extremities (and in some definitions, the face). Infections often spread to the neck and wrists of adults in contact with infected children. Anthropophilic organisms that cause tinea corporis include *T. rubrum* and *E. floccosum*, which infect the skin but not the hair, as well as dermatophytes also found in tinea capitis, such as *M. audouinii, T. schoenleinii, T. tonsurans* and *T. violaceum.* Various zoophilic organisms such as *M. canis, T. verrucosum, T. equinum, T. mentagrophytes* and *M. persicolor*, as well as the geophilic organisms *M. gypseum* and *M. nanum* can also cause this form of tinea.

One or more lesions may be present in tinea corporis. These lesions are usually pink to erythematous or scaly, and annular with a slightly elevated, scaly and/or erythematous edge, sharp margin, and central clearing. Follicular papules, pustules or vesicles may be found on the borders, especially when the lesion is caused by zoophilic or geophilic organisms. The zoophilic organism *T. quinckeanum* can cause scutulae. In contrast, some anthropophilic dermatophytes can cause chronic lesions with little inflammation and very little scaling at the edge. Lesions are variably pruritic. Treatment with corticosteroids, or repeated shaving or occlusion of the affected area, can result in skin lesions that do not resemble the classic form. Untreated tinea corporis may resolve within a few months, particularly if it is caused by a zoophilic or geophilic organism, but infections caused by anthropophilic organisms may be more persistent.

Tinea faciei and tinea barbae

Tinea faciei and tinea barbae are dermatophyte infections occurring on the face. These infections are often acquired from pets or livestock, but they can also be caused by anthropophilic dermatophytes that originally affected other parts of the body such as the scalp or torso.

Tinea barbae is an infection of the hairs and skin in the beard and mustache area, and is usually seen in men. Some causative organisms invade the hair and hair follicles, while others (e.g., *T. rubrum*) are limited to the skin. The lesions of tinea barbae may include scaling, follicular pustules and erythema. The zoophilic organisms *T. verrucosum* (associated with cattle) and *T. mentagrophytes* can cause a very inflammatory form of this disease, with pustular folliculitis or kerions. Some other species that may be involved include *M. canis*, which is zoophilic, and the anthropophilic organisms *T. tonsurans*, *T. megninii* and *T. violaceum.* Some authors consider tinea barbae to be a form of tinea faciei, rather than a separate condition.

Tinea faciei is seen on the nonbearded parts of the face. It can be caused by a number of anthropophilic and zoophilic organisms including *T. rubrum, T. tonsurans, T. schoenleinii, T. mentagrophytes, M. canis and T. erinacei*. The lesions are usually pruritic; itching and burning may become worse after exposure to sunlight. While some lesions may resemble those of tinea corporis, others have little or no scaling or lack raised edges. In addition, the areas of erythema may be indistinct. Due to these atypical presentations, tinea faciei is often confused with other skin diseases that affect the face.

Tinea cruris

Tinea cruris is an acute to chronic infection of the groin and adjacent areas, usually caused by anthropophilic dermatophytes. The most commonly involved organisms are *T. rubrum, T. mentagrophytes* var. *interdigitale* and

E. floccosum, although the last species is now uncommon in some areas. The symptoms include burning, pruritus, and erythematous lesions with scales, raised, sharply demarcated borders and central clearing. Pustules and vesicles are sometimes found at the edges of the lesion. Macerated, moist exudative forms or lesions with an eczematous appearance can be present in acute cases, while dry lesions with little scaling and an annular form are more characteristic of chronic cases. Hyperpigmentation is common in the central region as the lesion progresses. The same fungi can cause tinea cruris and tinea pedis, and the two conditions may be present concurrently.

Tinea pedis and tinea manuum

Tinea pedis is usually caused by anthropophilic dermatophytes such as *T. rubrum*, *T. mentagrophytes* var. *interdigitale* and *E. floccosum*. Interdigital tinea pedis (athlete's foot) is an infection of the foot, characterized either by dryness, fissures and scales or white, moist macerated lesions in some or all of the spaces between the toes. Another form of tinea pedis (the chronic, erythematosquamous or "moccasin" form) appears as scaling of the soles and lateral surfaces of the feet, with variable degrees of inflammation and dryness. A third form of tinea pedis is characterized by erythema, vesicles, pustules and bullae mainly on the soles of the feet. The nails are also involved in many cases.

Tinea manuum is a dermatophyte infection that tends to affect one hand, although involvement of both hands is possible. In this form, the palms become diffusely dry, scaly and erythematous. Inflammatory (vesicular or pustular) lesions can be seen occasionally. Tinea manuum is most often caused by anthropophilic dermatophytes, particularly *T. rubrum* (cases are frequently an extension of athlete's foot) but occasional cases may be caused by zoophilic organisms such as *M. canis*, *T. mentagrophytes*, *T. verrucosum* and *T. erinacei*, or the geophilic organism *M. gypseum*.

Tinea unguium

Tinea unguium (or onchomycosis) is a dermatophyte infection of the nails. It is characterized by thickened, opaque, discolored, broken and dystrophic nails. The nail plate may be separated from the nail bed. Toenails are affected more often than fingernails, and individual nails are sometimes spared. There are several different forms of tinea unguium, ranging from superficial, roughened white patches to almost complete breakdown of the nail. Most infections are caused by anthropophilic *Trichophyton* species, particularly *T. rubrum* and less frequently *T. mentagrophytes* var *interdigitale*. *M. canis* has been involved occasionally in immunosuppressed patients.

Dermatophytes in immunosuppressed individuals

In immunosuppressed individuals with impaired cell-mediated immunity (e.g., HIV-infected patients with low T cell counts, or organ transplant recipients), dermatophytes can cause extensive lesions. In rare cases, they may also penetrate more deeply into the skin than usual, resulting in abscesses, exophytic nodules, and pseudomycetomas (granulomatous or pyogranulomatous masses surrounding fungal hyphae). Although pseudomycetomas can also occur in healthy people, they are less common. Dissemination to internal organs (e.g., lymph nodes, bones, spleen, brain, liver) is possible, but very rare. Immunosuppressed patients may also be extensively infected with species that rarely affect healthy people, such as *M. gallinae*.

Communicability

Dermatophytes acquired from animals can be transmitted between people, but this is uncommon and the number of transfers is limited. In contrast, anthropophilic dermatophytes are readily spread from person to person.

Anthropophilic dermatophytes can be transmitted to animals, although this seems to be rare.

Diagnostic Tests

Diagnosis is based on the history, physical examination, and microscopic examination of scrapings and hairs from the lesions, sometimes in conjunction with fungal culture and other techniques such as Wood's lamp examination and histology of the tissues.

Some dermatophytes fluoresce when they are stimulated by the wavelengths of ultraviolet (UV) light in a Wood's lamp. Organisms that exhibit fluorescence include some strains of the zoophilic dermatophytes *M. canis* and *T. quinckeanum*, as well as a few anthropophilic species, such as *M. audouinii*. *T. tonsurans* and *T. violaceum*, which are the most common agents in some regions, are not revealed by this technique. Certain topical preparations may mask the fluorescence, and alcohol can either suppress it or cause non-specific fluorescence.

Dermatophytes can often be detected by microscopic examination of infected hairs and skin or nail scrapings. Hyphae rounding up into arthroconidia are diagnostic, but hyphae alone could be caused by other fungi, including contaminants. In hairs, arthroconidia may be found outside (ectothrix) or inside (endothrix) the hair shaft. Skin scrapings should be taken from the edge of the lesion, and hairs should be plucked (not cut) from this area. The best hairs to select are those that fluoresce under a Wood's lamp, or are broken or scaly. Nail scrapings are generally taken from the nail bed, or from deeper portions of the nail after removing the outer layers (except in cases where the infection is entirely superficial). Samples are usually cleared with potassium hydroxide (KOH) or other agents to help visualize the organism. Various stains such as chlorazol black E, Parker blue-black ink, Swartz-Lamkin stain or Congo red stain may be added. Fluorescence microscopy, using calcofluor white or other stains, can also be used to visualize dermatophyte structures.

Fungal cultures, which identify the species of dermatophyte, can be useful in understanding the source of the infection and targeting preventive measures

appropriately. Culture may also be necessary if the diagnosis is uncertain, or the infection is resistant to standard treatment. However, recommendations vary in the literature, and uncomplicated cases are not always cultured in practice. Samples for culture include hair, skin and nail samples, as for microscopic examination. In some situations (e.g., infections in sensitive sites, or the identification of asymptomatic carriers), other techniques such as brushing the hair, using adhesive tape to collect samples, or rubbing the area with a sterile toothbrush or moistened, sterile cotton swab may also be effective. Colonies appear in 5 days to 4 weeks, depending on the organism. Colony morphology can differ with the medium. Descriptions are usually based on Sabouraud agar, but dermatophyte medium or other fungal culture media can also be used for isolation. Dermatophyte species can be identified by the colony morphology; the appearance of microconidia, macroconidia and other microscopic structures; biochemical characteristics such as urease production; and nutritional requirements. Specialized tests such as the ability to penetrate hairs *in vitro*, or mating tests (which are usually available only at reference laboratories) may be used occasionally. Differential media (e.g., bromocresol purple-milk solids glucose) can be helpful during differentiation. Some fungal cultures from infected people are negative.

Histology (biopsy) is occasionally helpful, especially in deep mycoses and some infections of the nails. The organisms are visualized best with periodic acid–Schiff (PAS) staining, although they may also be found in hematoxylin-eosin stained preparations.

PCR tests have been published for a number of organisms, and molecular methods of diagnosis might become more common in the future.

Treatment

Dermatophyte infections are treated with a variety of topical and oral antifungal drugs.

In immunocompetent patients, topical agents are usually effective in cases that are limited to glabrous skin (e.g., tinea corporis, tinea cruris, and tinea pedis). Systemic (oral) antifungal drugs may be necessary in severe cases, or if the infection does not respond to treatment or reappears.

Topical agents are ineffective against organisms that infect the hairs. These infections are usually treated with systemic antifungals, although topical lotions or shampoos are sometimes used concurrently to decrease shedding of fungi and spores, or to help treat kerions. Topical agents may also be used to treat asymptomatic carriers or prevent reinfection. Tinea capitis is reported to be more difficult to treat when it is caused by *M. canis* than *Trichophyton* spp. and may not respond as well to some drugs.

Dermatophyte infections of the nails (tinea unguium) are usually treated with oral antifungal drugs. Concurrent therapies may include debridement of the nail or nail avulsion.

Treatment should consider sources of reinfection, such as pets, family members or other close contacts. Some authors suggest treating all family members when the case is caused by certain anthropophilic organisms.

Prevention

Controlling dermatophytes in animals can prevent some cases of zoonotic dermatophytosis in humans. Infected animals should be treated, and the premises and fomites cleaned and disinfected as much as possible. (Some environments can be difficult to decontaminate.) Contact with infected animals should be limited, and gloves and protective clothing should be used if these animals are handled.

Better surveillance, improved living conditions and improved treatments can decrease the overall prevalence of anthropophilic dermatophytes, while hygiene, and prevention of contact are helpful in individual cases. Measures such as moisture control (e.g., in tinea pedis) are important in reducing susceptibility to some forms of tinea.

Morbidity and Mortality

Dermatophyte infections are common in people, although the prevalence varies with the climate and various risk factors including animal contact. Up to 60% of children may be affected by tinea capitis in some regions, and more than 50% of the population in some parts of Europe is reported to have tinea pedis. With the exception of tinea cruris (which is typically seen in adults), dermatophytosis is more common in children.

Exposure to dermatophyte spores does not always lead to infection. Skin injuries (e.g., burns, maceration or chafing), as well as high temperatures and humidity, increase susceptibility. For example, tinea cruris is more common in hot climates and in people who wear tight clothing.

Most dermatophyte infections are not serious in healthy people, although some conditions are easier to treat than others. Infections in glabrous skin usually resolve within 2-4 weeks with treatment. In contrast, dermatophytosis of the nails may be difficult to cure (although the prognosis is better with newer drugs), and relapses can occur. In addition, damaged nails do not always return to a normal appearance even if the fungal infection is eliminated. Infections with opportunistic bacteria can cause cellulitis in skin damaged by interdigital fungal infections, and are a particular concern in diabetics.

Dermatophytosis has the potential to be more serious in immunosuppressed individuals, who may have atypical and locally aggressive dermatophyte infections, including extensive skin disease and subcutaneous abscesses, Disseminated disease is also possible, though very rare.

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Infections in Animals

Species Affected

All domesticated mammals are susceptible to dermatophytes. Wildlife can also be affected. The most common agents vary with the host and the geographic region, and may also be affected by management practices (e.g., whether animals can contact other species). Overall, the most common dermatophytes in domesticated mammals are *M. canis, M. gypseum, T. mentagrophytes, T. verrucosum, T. equinum* and (in pigs) *M. nanum*. Birds can also be affected by some organisms, such as *M. gallinae* and *T. mentagrophytes*.

Reptiles are not usually affected by the dermatophytes of mammals or birds; however, rare clinical cases associated with *Trichophyton* spp. have been reported in lizards, snakes (green anacondas, *Eunectes murinus*) and an olive ridley sea turtle (*Lepidochelys olivacea*). One case report in iguanas identified the species as *T. interdigitale*, possibly of anthropophilic origin.

Zoophilic dermatophytes

- *Microsporum canis* is the most common species of dermatophyte in cats and dogs, with cats considered to be the most important reservoir hosts. This organism is also found regularly in horses and rabbits, and it has been reported in other animals including cattle, sheep, goats, camelids and swine. Isolates that appear to be adapted to horses were previously called *Microsporum equinum*, but were moved to *M. canis* based on genetic analyses.
- *Microsporum gallinae* occurs in birds, including poultry. This organism seems to be uncommon in wild birds. Infections are reported occasionally in mammals including livestock, especially in some parts of the world.
- *Microsporum persicolor* primarily affects wild rodents (bank voles and mice). It is found occasionally in other species, especially rabbits and pigs, and dogs that burrow and hunt rodents. This organism infects the skin, but does not invade hairs.
- *Trichophyton bullosum* has been found in horses. It is related to *T. verrucosum.*
- *Trichophyton equinum*, adapted to horses, is an important cause of dermatophytosis in this species. Infections have also been reported in cats, dogs, goats, sheep and other species.
- *Trichophyton langeronii* seems to be adapted to camels.
- *Trichophyton mentagrophytes* has been reported in many species of animals, especially rodents and rabbits. It also affects horses, ruminants, swine, cats, dogs, birds and other hosts.
- *T. mentagrophytes* var. *erinacei* (or *T. erinacei*) occurs in the European hedgehog (*Erinaceus europeus*) and the African hedgehog (*Atelerix albiventris*). It is seen in pet hedgehogs as well as animals in the wild. This organism sometimes occurs in hunting dogs.
- *T. mentagrophytes* var. *granulosum* affects rodents. One group of organisms, (identified as "the *Trichophyton* anamorph of *A. benhamiae"* in the ITS taxonomy) is often associated with guinea pigs, and appears to the most common dermatophyte in this species.
- *T. mentagrophytes* var. *quinckeanum* has traditionally been associated with mice. However, it is considered to be a camel-associated isolate in the ITS genetic taxonomy.
- *Trichophyton sarkisovii* seems to be adapted to camels.
- *Trichophyton simii* affects nonhuman primates, but some authors believe the primary host is a ground-dwelling animal. It has also been reported from other mammals and birds.
- *Trichophyton verrucosum*, which is adapted to cattle, is the most important dermatophyte in this species. *T. verrucosum* readily infects other hosts, especially sheep, goats, South American camelids and camels, but it can also be found occasionally in other species such as horses, donkeys, pigs, dogs and rabbits.
- *T. verrucosum* var. *autotrophicum* affects sheep.

Geophilic species

- *M. gypseum* is detected occasionally in a wide variety of animals, including cats and dogs, ruminants, camelids, horses, pigs, rodents, rabbits, birds and others. It is the most frequently isolated geophilic dermatophyte in animals.
- *M. nanum* is the most important agent in swine. This dermatophyte is thought to be uncommon in most other species, although it has been found occasionally in rabbits and cattle.

Anthropophilic species

Anthropophilic dermatophytes are reported infrequently in animals (although it is possible that some of these reverse zoonoses are missed). Some species that have been documented in case reports include *M. audouinii, T. schoenleinii, T. rubrum, T. tonsurans, T. violaceum* and *E. floccosum*. Livestock (e.g., a goat) as well as pets have been infected. Potential predisposing factors, such as tumors or treatment with immunosuppressive drugs, were reported in some cases.

Incubation Period

Fluorescence produced by some dermatophytes, such as *M. canis*, can appear on the fur within 7 days of exposure, and clinical signs can develop within 2 to 4 weeks.

Clinical Signs

Dermatophytes usually grow only in keratinized tissues such as hair, nails and the outer layer of skin; the fungus stops spreading where it contacts living cells or areas of inflammation. Mucus membranes are not affected.

Dermatophyte lesions in animals are characterized by areas with varying degrees of alopecia, scaling, crusts and erythema, and may or may not be pruritic. Hairs in the affected area are usually brittle and break near the skin surface, often giving the lesion a "shaved" appearance; truncated hair shafts may be seen through the scales and crusts. Occasionally, dermatophytes may die at the center of a lesion and that area resolves, leaving a circular lesion with central crusts or hair regrowth. Some degree of folliculitis occurs in most cases; papules or pustules involving the hair follicle or conical dilation of the hair follicle ostium are suggestive of dermatophytosis in small animals. Asymptomatic infections are also common, particularly in adult animals.

Cats

Many cats infected with dermatophytes have few or no lesions. Long-haired adults, in particular, can be subclinical carriers or have only minimal signs, such as patchy areas of short stubble, alopecia, scales or erythematous plaques, visible only on close inspection. More apparent cases tend to be seen in kittens, with the early lesions often found on the face, ears and paws. In addition to focal alopecia and scales, affected areas may develop a thin, grayish white crust or a thick, moist scab. They may or may not be pruritic. The cat's grooming behavior may eventually spread the infection to the entire body. Other presentations that have been reported in cats include miliary dermatitis and recurrent chin acne. Severe cases of dermatophytosis, with large, erythematous, alopecic, exudative lesions, may be seen in debilitated cats, or in animals that have been treated with corticosteroids. Onchomycosis can occur concurrently in cats with dermatophytosis; the nails may be opaque, with whitish mottling, and shredding of the nail surface.

In some cats, dermatophytosis may appear as one or more firm, subcutaneous nodules known as pseudomycetomas, Pseudomycetomas tend to occur in long-haired cats, especially Persians, and are most often found on the back and the neck. They sometimes ulcerate or form draining sinus tracts. Some cats, but not others, have concurrent cutaneous signs such as alopecia and scaling. True mycetomas have also been reported, though rarely.

Uncomplicated dermatophyte lesions are usually self-limiting within a few weeks to a few months in short-haired cats; however, the organisms may persist, either symptomatically or asymptomatically, in long-haired cats.

Dogs

Dermatophytosis is seen most often in puppies. The lesions frequently develop on the face and limbs, although they may occur on any part of the body. *M. canis* tends to appear as small circular areas of alopecia. The hairs are typically broken at the base, giving the appearance of having been shaved. The center of the lesion usually contains pale skin scales in the early stage, giving it a powdery appearance, and the edges are generally erythematous. Vesicles and pustules may also be seen. In later stages, the area is often covered by a crust and the edges swollen. Individual lesions may coalesce to form large, irregular patches. Lesions caused by *T. mentagrophytes* and *T erinacei* tend to be more thickened and inflammatory than those caused by *M. canis*,. while *M persicolor* typically causes localized or generalized scaling with little erythema and minimal alopecia. Other forms of dermatophytosis can include kerions (localized severe inflammation with swollen, boggy skin oozing pus) and pseudomycetomas. Onchomycosis may occur concurrently with dermatophytosis.

Although dermatophytosis is often self-limited in dogs, some animals can develop severe, chronic cases with widespread lesions, and severe inflammation and alopecia. Generalized cases in adult dogs usually occur in immunosuppressed animals, especially those that have hyperadrenocortictropism or have been treated with corticosteroids.

Horses

In horses, most dermatophyte lesions are found in areas of contact with saddles or other tack. They usually begin as small patches of raised hairs, and progress to hair loss, with variable amounts of scaling, erythema, crusting and exudation. *M. canis* lesions are reported to be milder, in most cases, than *T equinum*. Kerions may occur in some animals, especially on the face. Miliary dermatitis may also be seen, with small crusted lesions especially on the flanks. Early dermatophyte lesions can sometimes resemble papular urticaria, but more characteristic signs develop within a few days. Lesions may coalesce, especially where the skin is abraded from tack.

Cattle

In cattle, dermatophytosis varies from small focal lesions to extensive generalized skin involvement. The initial lesions may be discrete, scaly and alopecic with grayish-white crusts, and tend to appear on the face and neck in calves. Cows and heifers may have lesions more often on the chest and limbs, and bulls on the dewlap and intermaxillary skin. Some areas may become suppurative and thickly crusted. Lesions resembling light brown scabs may also be seen; when these scabs fall off, they leave an

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area of alopecia. The clinical signs usually resolve spontaneously in 2 to 4 months.

Sheep and goats

Dermatophytosis tends to be seen in show lambs, but appears to be uncommon in production flocks. The most noticeable signs are usually circular, alopecic areas with thick scabs on the head, face and non-wooled areas of the legs; however, widespread lesions may be found under the wool when lambs are sheared for showing. In healthy lambs, the disease is usually self-limiting.

Swine

Pigs may develop a wrinkled lesion covered by a thin, brown, easily removed scab, or a spreading ring of inflammation. Dermatophyte infections are often asymptomatic in adult swine.

Rodents

Most rodents infected with *T. mentagrophytes* are asymptomatic or have few clinical signs. There may be areas of partial or complete alopecia, erythema, scales, and crusts in symptomatic animals. In guinea pigs, the lesions tend to appear first on the face, then spread to the back and limbs. In mice, the lesions are often found on the tail.

Rabbits

Focal alopecia, with erythema, crusts, scales and scabs, is initially seen mainly around the eyes, nose, ears and dorsal neck. The lesions may later spread to other areas of the body. The disease is usually self-limiting.

Hedgehogs

Asymptomatic infections are common in hedgehogs. In symptomatic animals, scales may be found on the head, base of the nails and under the pads, but lesions are difficult to see between the spines.

Birds

In cage birds, there may be alopecia and scales, particularly on the face, head, neck and chest, as well as auto-mutilation and feather plucking. The head and neck, especially the comb, are often affected in fowl. The lesions may include white crusts or plaques and hyperkeratosis. Although feathers may be lost in birds, they are not infected.

Reptiles

Reptiles are not usually affected by the dermatophytes of mammals or birds; however, there are rare case reports of dermal lesions in lizards and green anacondas. Clinical signs reported during a *Trichophyton* outbreak in iguanas included scaling, crusting, thickening of the skin and ulcerative dermatitis. *Trichophyton* spp. infection was associated with papular and pustular cutaneous lesions in a Tenerife lizard. This animal died of an undetermined illness, soon afterward. *Trichophyton* spp. was also detected by immunohistochemistry from systemic lesions in a moribund sea turtle.

Communicability

Most animal dermatophytes are readily transmitted to other susceptible hosts, including humans, by contact and contamination of the environment. *M. nanum* of pigs and *T. gallinae* of birds are generally reported to be uncommon in healthy people; however, this may not be the case in all locations. One study found that *T. gallinae* was the third most frequent dermatophyte of children in Nigeria.

Post Mortem Lesions

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Gross post-mortem lesions are usually identical to those in live animals; with the exception of pseudomycetomas and mycetomas, dermatophytes are restricted to the hair, nails and superficial skin.

Diagnostic Tests

Dermatophytosis is usually diagnosed by a combination of direct microscopic examination, culture and Wood's lamp examination. Biopsy (histopathology) tends to be used mainly when the presentation is unusual.

A Wood's lamp examination for fluorescence can be helpful in detecting some species of dermatophytes, such as *M. canis* and *T. quinckeanum.* Not all strains of these organisms exhibit fluorescence. Certain topical preparations may mask the fluorescence, and alcohol can either suppress it or cause non-specific fluorescence.

Microscopic examination of skin scrapings or plucked hairs may reveal hyphae or arthroconidia. Hyphae rounding up into arthroconidia are diagnostic; however, hyphae alone could be caused by other fungi, including contaminants. Samples should be selected from the margins of active lesions, or from the entire lesion if there is no inflammatory margin. The best hairs to select are those that fluoresce under a Wood's lamp, or are broken or scaly. Samples are usually cleared with potassium hydroxide (KOH) to help visualize the organism, although other clearing agents may be used. A longer clearing time can be helpful when the hair is thicker and more heavily pigmented, or if the sample is taken from a thick, crusted lesion. Various stains such as chlorazol black E, Parker blue-black ink, Swartz-Lamkin stain, Congo red stain or Giemsa can aid the visualization of fungal structures. In practices where fluorescence microscopy is available, calcofluor white staining can be used.

Skin scrapings or plucked hair samples for culture should be taken from active lesions, as for microscopic examination. Nail beds and claws are cultured in cases of onchomycosis. Swabbing dermatophyte lesions first with alcohol may decrease contaminants, especially in livestock. Additional collection methods, which are especially helpful in asymptomatic animals suspected of being carriers, including brushing the fur with a disinfected toothbrush or other small brush, or rubbing it with a sterile piece of carpet.

Dermatophytes can be cultured on various fungal media, including Sabouraud agar (with cycloheximide and antibiotics) and dermatophyte test medium (DTM). Cultures are usually incubated at room temperature (20–28ºC), but higher temperatures can be used when certain organisms (e.g., *T. verrucosum*) are suspected. Colonies often become visible within 1-2 weeks but, some species grow more slowly and may require longer to appear. Colony morphology can differ with the medium; descriptions are usually based on Sabouraud agar. DTM contains a pH indicator (phenol red) that will turn the medium red when a dermatophyte is growing. However, the mycelial growth must also be examined microscopically, as this color change alone is not diagnostic and could be produced by other fungal or bacterial organisms. In addition, the color change may be delayed with certain dermatophytes such as *M. persicolor*. In asymptomatic animals, caution must be used to distinguish infection from contamination of the coat with organisms from the environment.

Dermatophyte species can be identified by the colony morphology; the appearance of microconidia, macroconidia and other microscopic structures; biochemical characteristics such as urease production; and nutritional requirements. Microconidia and macroconidia can be used to distinguish the genera *Microsporum*, *Trichophyton* and *Epidermophyton*. Members of *Microsporum* spp. produce microconidia and rough-walled, multiseptate macroconidia. The thickness of the wall, shape and number of macroconidia vary with the species. *Trichophyton* spp. produce microconidia and smooth, thin-walled, cigar shaped macroconidia. Macroconidia are rarely seen with some species. *E. floccosum*, which is anthropophilic and has very rarely been reported in animals, produces large, thin-walled, multicellular, club-shaped, clustered macroconidia. This organism does not produce microconidia. Specialized tests, such as the ability to penetrate hairs *in vitro*, or mating tests performed at reference laboratories, may occasionally be used in the differentiation process. Differential media (e.g., bromocresol purple - milk solids glucose) can also be helpful.

Histology may be used in some cases, especially in animals with pseudomycetomas. The organisms are visualized best with periodic acid–Schiff (PAS) staining, although they may also be found in hematoxylin-eosin stained preparations.

PCR tests have been published for a number of organisms, including zoophilic organisms, and molecular methods of diagnosis might become more common in the future.

Treatment

Healthy animals often have self-limiting infections that resolve within a few months, but treatment can speed recovery, prevent the lesions from spreading, and decrease the risk of transmission to people or other animals. Some individual animals, particularly those that are debilitated or unusually susceptible, may not clear the infection without treatment.

Drugs available to treat dermatophytosis in animals include topical antifungal creams or shampoos, and systemic antifungals. The same treatment principles apply in animals as people; however, practical considerations limit the use of systemic antifungals in some species. Topical drugs are unable to eliminate dermatophytes from within hairs and hair follicles, but they may be effective against organisms in superficial sites (e.g., in the skin), and they can decrease contamination and transmission to others. The optimal treatment in small animals is combined topical and systemic treatment. Systemic antifungals are rarely used in large animals, due to the cost of these drugs and the typically self-limited nature of the disease. The side effects of systemic drugs should also be taken into consideration when choosing a treatment plan. Clipping the hair before treatment is controversial. It may aid the penetration of topical drugs, as well as remove infected hairs. However, it may also result in trauma to the skin and help disseminate the infection. If the animal is clipped, this should be done with care.. Some animals such as cattle develop thick crusts, which should be removed by gentle brushing.

Onchomycosis can be very difficult to cure; long term treatment or surgical declawing may be necessary. Pseudomycetomas and mycetomas are also reported to be difficult to treat, often recur after surgery, and may not respond to some drugs. Nevertheless, some cases have been treated successfully with drugs and/or surgery.

Animals should be isolated until the infection resolves. Confining the animal to an environment that is easily cleaned can facilitate environmental control. Dermatophytes can be difficult to eradicate from environments such as kennels, catteries and animal shelters.

Prevention

To prevent the introduction of dermatophytes into herds or kennels, newly acquired animals should be isolated and cultured. Wild rodent control can decrease exposure to *T. mentagrophytes*. Some organisms can be acquired by contact with infected soil.

To prevent infected animals from transmitting dermatophytes to others, they should be isolated until the infection has resolved. The premises should be cleaned and disinfected. Some environments (e.g., barns) may be difficult or impossible to decontaminate completely. Animals that have been in contact with the patient should be checked for asymptomatic infections. Some veterinarians use topical antifungals prophylactically for in-contact animals. Dermatophytes can be difficult to eradicate from environments such as kennels, catteries and animal shelters. Successful treatment of these premises must be based on good environmental control, as well as treatment of symptomatically and asymptomatically infected animals.

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Vaccines are available in some countries for certain organisms, such as *T. verrucosum* and *T. mentagrophytes* in livestock, farmed foxes, chinchillas and rabbits; *T. equinum* in horses; and *M canis* in cats and dogs. A feline vaccine licensed for *M. canis* in the U.S. was found to be ineffective under field conditions, and was withdrawn by the manufacturer in 2003. Studies of other vaccines have demonstrated varying efficacy.

In some countries, vaccines have been used in dermatophyte eradication campaigns for cattle. In Norway, there is a program to eradicate *T. verrucosum* from cattle herds by vaccination, disinfection of contaminated stables, isolation of infected animals and good hygiene. In one region of Norway, where 95% of herds participated, the prevalence of cattle ringworm decreased from 70% to 0% over a period of 8 years. In the former Soviet Union, a vaccination campaign reduced the prevalence of *T. verrucosum* in cattle to less than 1% by 1984.

Morbidity and Mortality

Whether an animal becomes infected after contact with a dermatophyte may depend on the animal's age, the condition of its exposed skin, general health and grooming behavior. Young animals, including puppies, kittens, calves, lambs and young camelids, are more likely to have symptomatic infections than adults. Clinical dermatophytosis is also thought to be more common in immunosuppressed animals. Most infections in healthy animals heal spontaneously within one to a few months. Hair loss is not permanent unless the follicle has been destroyed by inflammation. Infections can be more persistent or widespread in young or sick animals. Breeds reported to more susceptible to dermatophytes include some long haired cats, and possibly Yorkshire terriers. Long-haired cats, especially Persians, are also more likely to develop pseudomycetomas and mycetomas.

Dermatophytes can be isolated from animals with or without clinical signs. Highly variable infection rates, between 6% and 100%, have been reported in surveys of cats, which are thought to carry these organisms more often than dogs. Infections are especially prevalent in strays and in catteries. The estimated prevalence among pet cats and dogs in individual households is still unclear. While some surveys suggest that many cats are infected with these organisms, one University of Wisconsin study did not detect dermatophytes in any of 182 asymptomatic pet cats that lived alone with their owners.

Among livestock, dermatophytes are particularly common in cold climates where animals are stabled for long periods of time. This disease usually becomes endemic in cattle herds, where it most often affects animals under a year of age. The lesions tend to develop in cattle when they are stabled indoors in winter, and to resolve when they are turned out in the spring.. Clinical cases do not seem to be common in sheep and goats, with the exception of show lambs; however, *M. canis* caused some outbreaks that affected 20-90% of sheep herds in Australia. It is possible that cases are underdiagnosed in small ruminants. Infected animals are reported to be common on rabbit farms in some countries. Clinical cases seem to be infrequent in birds.

Internet Resources

Centers for Disease Control and Prevention (CDC)
http://www.cdc.gov/healthypets/diseases/ringworm.htm

Canadian National Centre for Mycology. World of Dermatophytes: A Pictorial
http://www.provlab.ab.ca/mycol/tutorials/derm/dermhome.htm

National Institutes of Health
http://www.nlm.nih.gov/medlineplus/ency/article/001439.htm

The Merck Manual
http://www.merck.com/pubs/mmanual/

The Merck Veterinary Manual
http://www.merckvetmanual.com/mvm/index.jsp

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